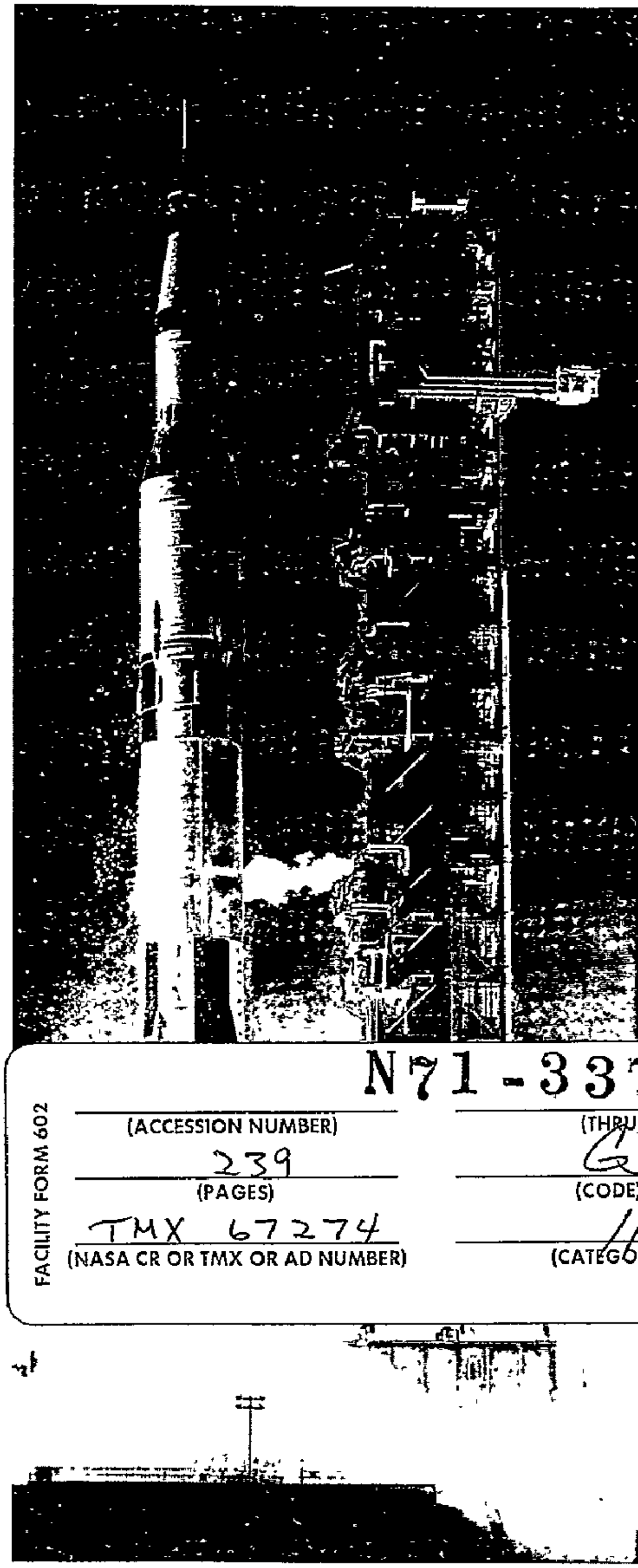

The Kennedy Space Center Story

JOHN F. KENNEDY SPACE CENTER, PA

JUNE 1970

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Kennedy Space Center, Florida 32899

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Dr. Thomas O. Paine
Administrator, National Aeronautics and Space Administration

Dr. Paine became NASA's Deputy Administrator March 25, 1969 and the Acting Administrator upon retirement of James E. Webb October 8, 1968. He was appointed Administrator by President Richard M. Nixon March 5, 1969.

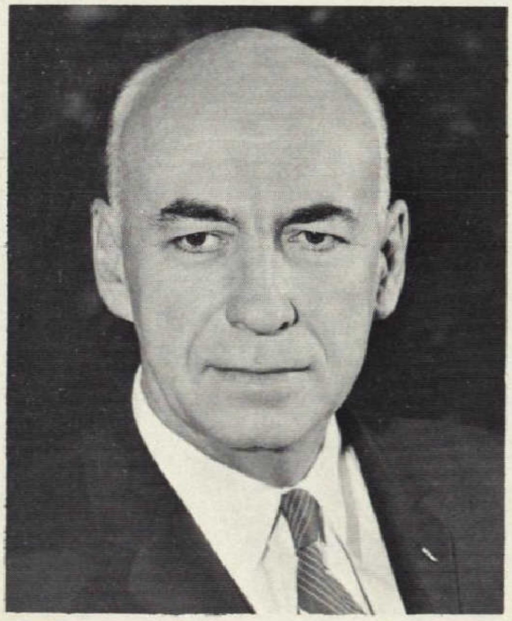
Dr. Kurt H. Debus
Director, John F. Kennedy Space Center, NASA

Dr. Debus received degrees from Darmstadt University in mechanical and electrical engineering. He won his engineering doctorate in 1939 with a thesis on surge voltages and was appointed assistant professor at the University. During this period he became actively engaged in rocket research at Peenemuende and has remained in this field since. In recognition of his unique technical accomplishments, Dr. Debus received the U.S. Army's highest civilian decoration, the Scott Medal of the American Ordnance Association and NASA's Outstanding Leadership Award. The International Committee on Aerospace Activities presented its first Pioneer of Wind Rose award, Order of the Diamond, in July 1965. He received honorary Doctorate degrees from Rollins College in 1967, and Florida Technological University in 1969. He received the Daughters of the American Revolution Americanism Award and was elected to the National Space Hall of Fame in 1969.

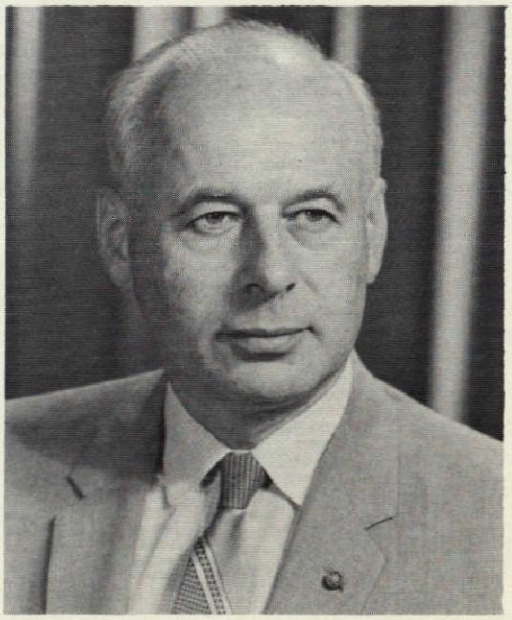
Dale D. Myers
Associate Administrator
Manned Space Flight

Dr. Rocco A. Petrone
Apollo Program Director
Office of Manned Space Flight

Dr. Robert R. Gilruth
Director
Manned Spacecraft Center



Dr. Eberhard F. M. Rees
Director
Marshall Space Flight Center



PRELUDE

John F. Kennedy had been President of the United States 16 days when three men met in a small office on Cape Kennedy to discuss new concepts for launching heavy space vehicles. They were Dr. Kurt H. Debus, then director of the Marshall Space Flight Center launch team; Theodor A. Poppel and Georg von Tiesenhausen. All three had spent 25 years in rocket development.

Dr. Debus asked his colleagues to study new launch sites for rockets of between 5,000,000 and 10,000,000 pounds thrust. This was just three years after the team launched America's first satellite with a rocket that developed 87,000 pounds thrust, and when preparations were underway to launch U.S. astronauts aboard Redstone rockets and the more powerful Atlas which developed 388,000 pounds thrust.

On March 22, 1961, Dr. Debus brought Albert Zeiler, another associate of many years; Dr. Hans F. Gruene, his deputy; Rocco A. Petrone, Raymond L. Clark and others into the planning. He appointed Zeiler chairman of the group to consider new concepts for checkout and launch of rockets which did not exist, assessing the pros and cons of horizontal versus vertical assembly in an area removed from launch zone hazards, transferring the assembled vehicle to the firing site by rail or other means, and increasing the potential launch rate from a given fixed pad or firing site. Dr. Debus reasoned that it was uneconomical and inefficient to continue assembling vehicles on the costly launch pads because of the low utilization rate this imposed, and because he well understood that rockets of the magnitude then under discussion would represent large investments in the most complex systems yet contemplated for space flight.

Nine days later, Dr. Debus appeared before the Marshall Center's Management Board, chaired by Dr. Wernher von Braun and outlined his concepts. On April 12, the Soviet Union launched the first man into orbit in a six-ton spacecraft. In the next three weeks there was a flurry of constructive study throughout NASA in response to questions from the White House as to what technical goals should be established as clear targets to capture and hold leadership for the United States in this new frontier. Any of the proposals which were evolved required the development of much larger and more powerful rockets than were available. President Kennedy determined that a manned landing on the Moon was the most feasible approach. He announced this objective May 25th as a national goal to be accomplished within that decade.

Dr. Debus then presented his ideas to Dr. Robert C. Seamans, the late Dr. Hugh Dryden, and other senior NASA officials. They approved his plans for Launch Complex 37 to accommodate the Saturn rocket being developed by the Marshall team and authorized him to undertake feasibility studies for a major launch base that would become world famous as Complex 39, from which astronauts depart for the Moon. He returned from Washington, called together his staff, including Rocco Petrone upon whom much of the planning work was to fall, and set the machinery in motion to create the Free World's first operational Spaceport.

This is the story of a dream that became a reality November 9, 1967, when the first Apollo/Saturn V configuration lifted off Pad A of Complex 39 and carried into Earth orbit an assembly weighing 285,000 pounds, by far the heaviest mass which human ingenuity, intricate equipment, and a high sense of dedication had ever hurled into space.

The reality assumed even more portentous significance when on December 21, 1968, the third Apollo/Saturn V thundered majestically into the heavens carrying Astronauts Frank Borman, James Lovell and William Anders on man's first voyage to the Moon — an achievement that stirred the hearts and minds of all mankind. As he contemplated the magnificent performance of the astronauts, Dr. Debus remarked: "Now we can truly explore the solar system and then the Universe."

The stage was set for the culmination of Project Apollo. On July 16, 1969, seven months after the Apollo 8 triumph and following the successful Apollo 9 and 10 missions, Astronauts Neil Armstrong, Edwin Aldrin and Michael Collins lifted off Pad A to begin mankind's greatest adventure. At 4:15 P.M. EDT July 20, while millions listened in awe, Neil Armstrong spoke the fateful message.

"Houston, Tranquility Base here. The Eagle has landed."

Earthman had found a new dimension and Apollo had achieved the objective towards which thousands had labored for eight years.

Gordon L. Harris, June 1, 1970

I

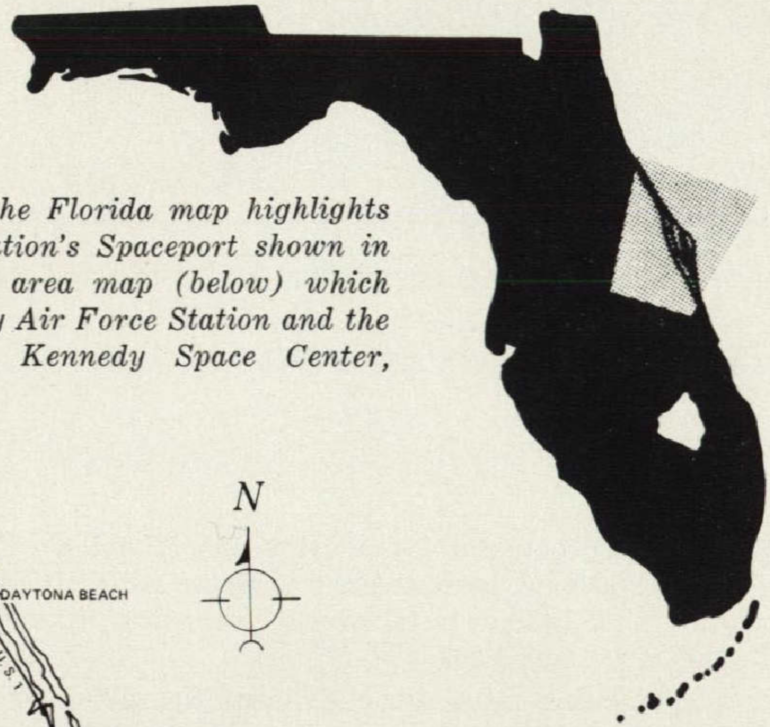
The Spaceport, A National Resource

MIDWAY between Jacksonville and Miami, on Florida's East Coast, the National Aeronautics and Space Administration has constructed a giant installation from which astronauts have traveled from Earth to the Moon and back.

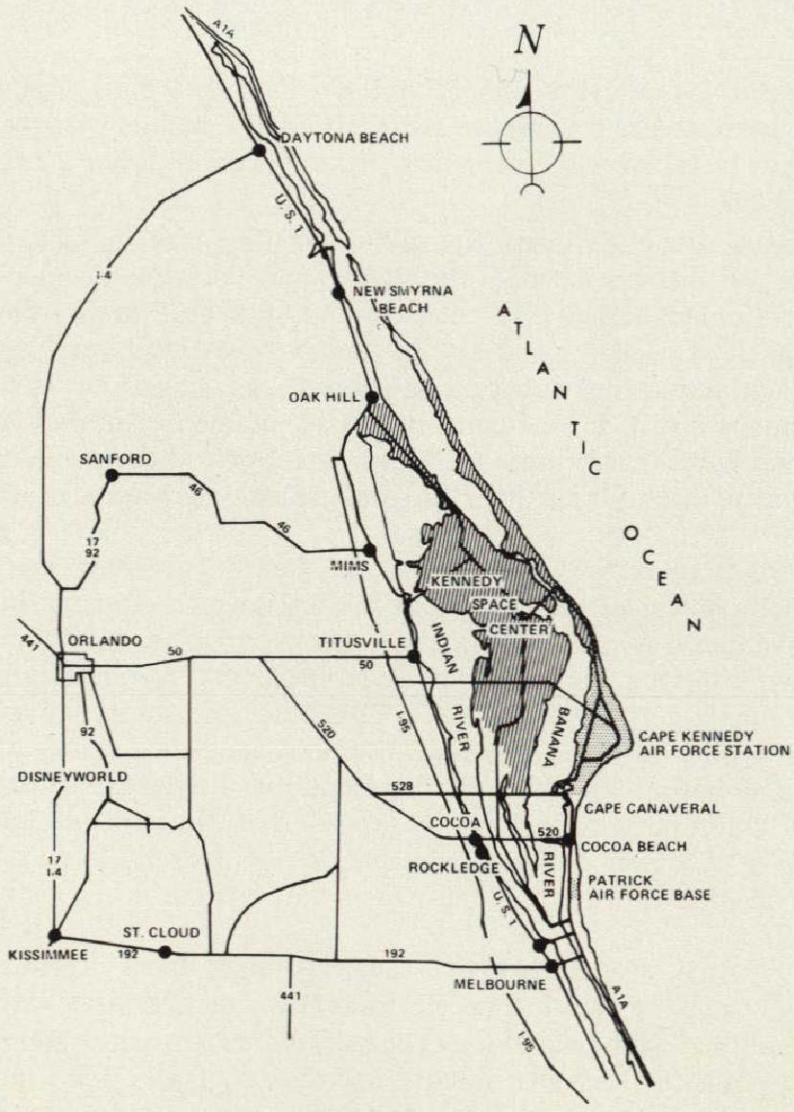
That event assured the Kennedy Space Center its place in history. But later manned adventures beyond the Moon may overshadow even the first return of human beings who visit another planet. For the men formulating the national space program in Government, industry and universities are contemplating future possibilities as novel as space stations in permanent orbit for astronomical and biomedical missions, manned and unmanned expeditions to Mars, scientific bases on the Moon and eventually discovering life in some form elsewhere in the Universe.

Uniquely a creation of the Space Age, the Center presents sharp contrasts between its physical setting, early history and the gargantuan engineering achievements which transformed palmetto scrub, marshland and citrus groves into the first operational Spaceport. Archeologists found traces of human activity before the Christian era, Indian burial mounds and refuse piles of later times, and indications of French and Spanish explorations before the birth of the Republic. Professor Charles Fairbanks of the University of Florida observed that the site was one of the places where Western civilization came to the New World; now it is destined to become the place from which our civilization goes out to other worlds.

What were virgin lowlands in 1961 today support huge steel-and-concrete buildings housing engineers, technicians and administrators engaged in assembling and launching spacecraft within the Merritt Island National Wildlife Refuge. Where astronauts train for space missions and rockets lift off with thunderous roar, duck hunters



The shaded area on the Florida map highlights the location of the nation's Spaceport shown in greater detail on the area map (below) which includes Cape Kennedy Air Force Station and the 88,000-acre John F. Kennedy Space Center, NASA.



call their feathered quarry, fishermen ply the waters of the adjacent Indian and Banana Rivers, Boy Scouts camp, surfers slide over Atlantic Ocean waves, seasonal workers harvest oranges and grapefruit, bee-keepers tend their hives and thousands of visitors tour daily in buses.

Directing the immense establishment is a quiet, soft-spoken engineer, Dr. Kurt H. Debus, foremost authority on launch technology, who came to the United States in the late 1940s with Dr. Wernher von Braun, master rocket builder, and 120 other former German scientists and engineers who voluntarily chose American citizenship at the close of World War II. They had pushed the development of rocketry to new levels at Peene-muende where they dreamed of space flight and brought with them invaluable experience that facilitated the development of weapons sys-tems for the national defense.

Dr. Debus played a vital role in the selection and design of the NASA Spaceport which bears little resemblance to the modest launch facilities he supervised on Cape Kennedy, across the Banana River, while launching U.S. Army missiles from 1953 to 1960. Early versions of the Redstone and Jupiter systems were fabricated at Redstone Arsenal, Alabama, by the von Braun team and turned over to the Missile Firing Laboratory headed by Debus. With 75 to 90 technicians, he would pack bags and accompany the truck-transported rocket to the Cape, set it up on the launch pad, fire it and then return to Alabama to await the next rocket off the line. Subsequently, the launch team relocated to the Cape Kennedy area and flight tested many Redstones and Jupiters built by Chrysler Corporation.

In the course of his eventful years in Florida, Dr. Debus has been host at the Center to Presidents of the United States and Vice Presidents — attesting to their keen interest in the exploration of outer space, as well as to the elected leaders or rulers of many Free World nations, attracted to the site where history has been made, and more portentous events await future launches.

Rockets and spacecraft required for the space program have grown so large that some can be transported only by ocean barges or special purpose cargo aircraft known as Guppies, in the case of Saturn V and Apollo, from manufacturing and testing sites in Mississippi, Alabama, Long Island and California. The fuselage of the Guppies doubles or triples the cargo space in order to accommodate the huge stages and spacecraft.

The small launch crew headed by Dr. Debus in the early 1950's has multiplied many times into an organization of approximately 20,000, most of whom are employed by aerospace firms who build the launch vehicles and spacecraft, and other firms providing common services to the Govern-ment cadre, numbering 3,000, and their industrial teammates. The Gov-ernment's role involves planning, coordination and supervision of the total effort.

Most of this growth occurred since 1962. In May 1961, the late

President Kennedy fired public imagination by announcing the United States would undertake to fly men to the Moon and back in this decade. This challenge won Congressional support for the Apollo program which called for the development of rockets far more powerful than any then on the drawing boards and spacecraft large enough to accommodate three men on the 500,000-mile round trip to the Moon.

To assemble, service and launch these novel space transportation systems, a suitable location had to be found. Cape Kennedy's 17,000 acres had been intensively developed for launching military rockets and the less powerful space boosters employed by NASA. These facilities were adequate for Project Mercury missions, flown on Atlas rockets; for Project Gemini, the two-man spacecraft launched on modified Titan rockets; and for unmanned, scientific space missions requiring Thor Delta, Atlas Agena and Centaur vehicles. At the northern end of the Cape, even as NASA came into existence in October 1958, the Army had begun preparations for a large complex to launch Saturn vehicles. NASA completed the work and built a second complex. Either will launch Saturn vehicles standing 220 feet tall and developing 1,600,000 pounds thrust, sufficient to lift a gross weight of 1,300,000 pounds off the launch pad and place 20 tons in Earth orbit.

Dr. Debus, representing NASA, and Lt. Gen. Leighton I. Davis, representing the Department of Defense, captained a joint study to find a new launch site. They considered Hawaii, the West Coast, the Texas coast, an island off the coast of Georgia, islands in the Caribbean and Merritt Island next to Cape Kennedy.

An island launch base offered recognized advantages. There would be no danger of spent or partially spent rockets falling back through the atmosphere and impacting on populated territory. On the other hand, to maintain a technically oriented population in such a remote facility would pose many problems.

There would need to be a community housing workers and their families, churches, schools, shops and the other institutions and conveniences to attract and retain a technical work force with a heavy percentage of highly trained engineers. But Merritt Island offered a compelling advantage in the opportunity to utilize the superb technical facilities of the Atlantic Missile Range built up by the Department of Defense under management of the U.S. Air Force, thus avoiding costly duplication. Also, there were communities on the island and nearby Florida mainland, cities like Daytona Beach and Vero Beach within easy driving distance, capable of absorbing the increasing population.

Only at this location could the same NASA launch organization continue operations on the Cape Kennedy complexes as well as build and operate the Spaceport and effectively integrate the overall launch activities. The northern part of Merritt Island was recommended by Dr. Debus and General Davis, promptly accepted by NASA and the Defense De-

partment, and confirmed by the Congress which authorized the acquisition. Implicit in this joint study and the subsequent approvals was the availability of the Spaceport for future military requirements as well as for the NASA programs.

Beginning in 1962, the space agency acquired 87,763 acres by purchase and also obtained from the State of Florida the right to use 53,553 additional acres of submerged lands, most of which lie within the Mosquito Lagoon, separated from the ocean by a narrow beach strip on the east and connected with the Indian River on the west by the Haulover Canal crossing Merritt Island. The investment in property has reached approximately $71,872,000.

The southern boundary of the Spaceport runs along a Barge Canal connecting Port Canaveral with the Banana and Indian Rivers and parallel to the southern tip of Cape Kennedy. The tract extends northward some 20 miles, almost as far as New Smyrna Beach, and is bounded by the Atlantic Ocean on the east and the Indian River on the west. It is large enough to accommodate the Apollo/Saturn V vehicles for the Moon excursion and other missions. Since a fully fueled Saturn V weighs more than 6,000,000 pounds and contains liquid oxygen, liquid hydrogen and jet fuel, it has been computed to represent an explosive potential equivalent to 1,000,000 pounds of TNT. In event of catastrophe, therefore, a clear area of 3.5 miles surrounding the launch pad is required to reduce hazards to personnel and buildings.

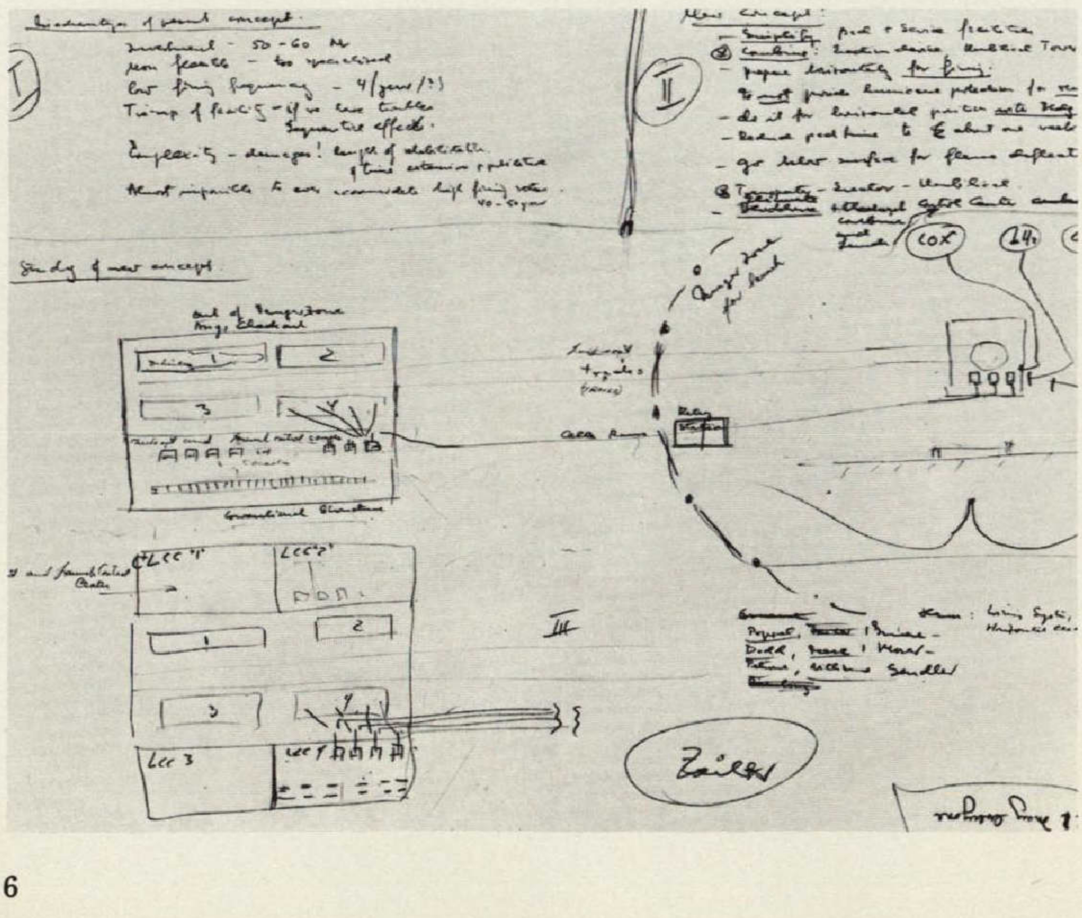
NASA sought to look ahead at the time of the land acquisition to the foreseeable demands of the future space program. Engineering studies determined there is sufficient area available within the installation to permit the construction and operation of an additional complex for the assembly and launch of vehicles of 35,000,000 pounds thrust, nearly five times more powerful than those which will be used for the manned trips to the Moon. Rockets of those formidable proportions would create another problem in the noise level generated by their giant engines. Consequently, the safety or buffer zone would expand as the rockets increased in dimensions.

The Spaceport may some day launch rockets with nuclear-powered upper stages that must be anticipated, either in the NASA or Defense programs, since the engines are already in development. As the master plan for the Spaceport was prepared, provisions were incorporated for additional facilities which might be constructed either for more powerful boosters or for configurations employing nuclear power plants, or both. The nuclear engine will greatly increase the propulsion force of spacecraft outside the Earth's atmosphere, reducing travel time to distant objectives and making possible manned flights far beyond the Moon.

From the outset, NASA has steadfastly maintained a good neighbor policy so that some aspects of the Merritt Island economy have remained essentially unaltered even while planners envisage trips to Mars. Within

the Federal reservation are 185,000 citrus trees planted on 3,306 acres. The groves were leased back to their former owners by the Government. They care for the trees and harvest the annual crops of fruit. In return for this privilege, they pay annual lease fees to the U.S. Treasury. Because pollination is essential to fruit production, the Space Center licenses 20 beekeepers who pay $625 in fees each year to maintain hives within the groves. Elsewhere in the Center are three fish camps open to anglers who take salt water trout, redfish and other food and sporting fishes from the Indian River and the Lagoon. Twenty-one homes are also leased by the Government. In turn, the occupants pay rentals to the Treasury. NASA fenced off three private burial grounds containing 19 graves

One of a series of drawings prepared by Dr. Kurt H. Debus in March 1961 comparing the advantages of vehicle assembly on the launch pad and the mobile concept of launch operations, with assembly and checkout in a protected environment removed from the immediate zone of fire, explosion and impact hazard at the launch pad. This drawing is his original sketch of an assembly building and launch control center.



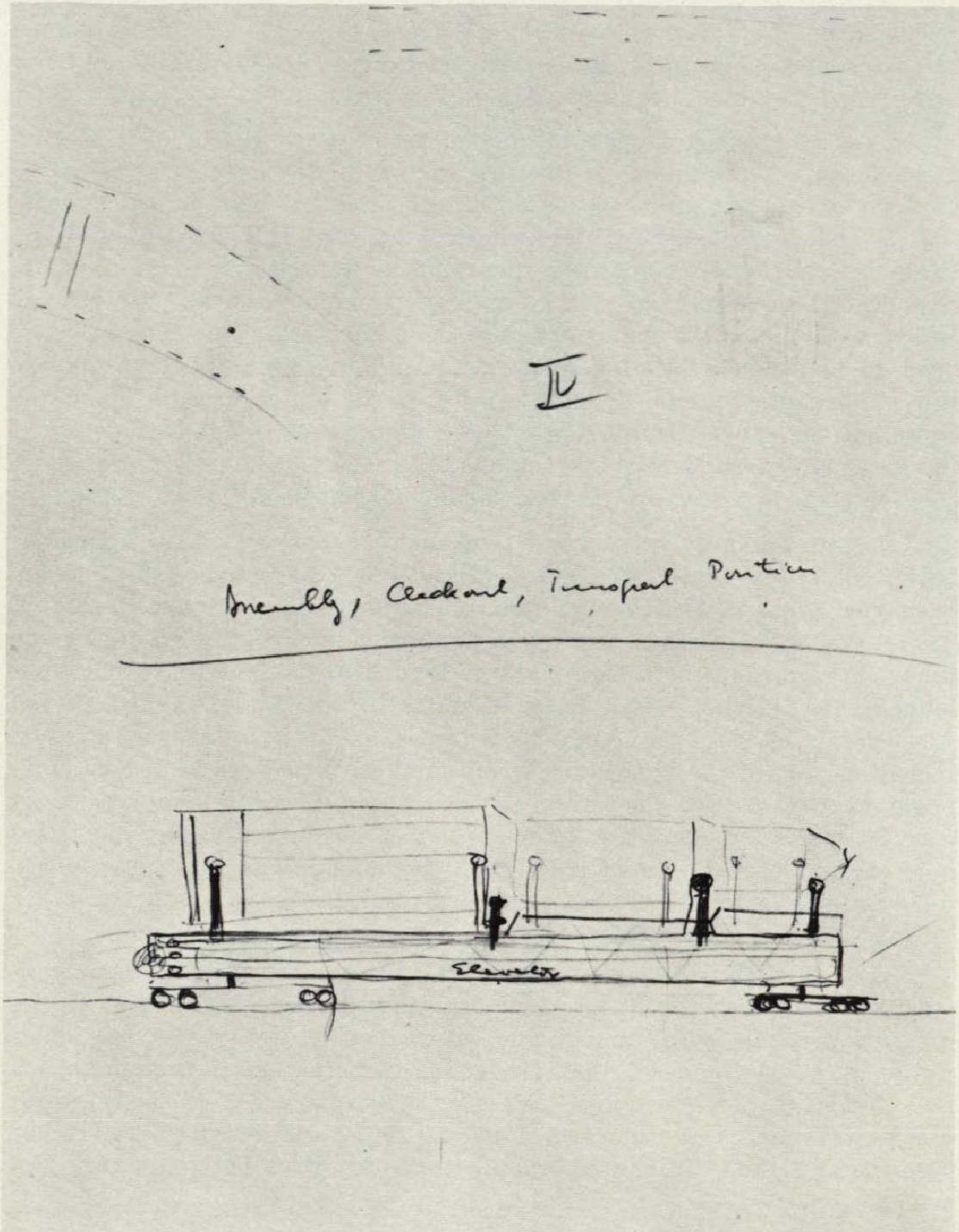
and permits relatives to visit them as they wish. A Baptist Church was relocated off Center. A second church acquired in the purchase became an office and laboratory. Summer homes along the Atlantic beachfront were converted to office and storage purposes.

Large areas are open for public recreational usage. One stretch of seashore is maintained by Brevard County under agreement with the Center. Lifeguards protect bathers in the Summer. The county reports that 300,000 persons visit the beach annually. The U.S. Bureau of Sport Fisheries and Wildlife operates the Wildlife Refuge and manages more than 83,000 acres of land and water area under agreement with NASA. Fresh water impoundments in the northern portion of the Spaceport are open to sportsmen fishing for largemouth bass and bream while the Bureau permits controlled duck hunting in 25 blinds erected along the Indian River shore. Hunters pay $3 for the use of a blind each day in the hunting season. They have commented that it is the only place where they can shoot waterfowl in the shadow of moon rockets.

Despite the daily presence of thousands of workers and the constant traffic of buses, trucks and autos, wildlife continues to inhabit the undeveloped areas of the Center, apparently inured to the rocket blastoffs. There are bobcats, raccoon, and alligators. Many kinds of ducks and other shore birds nest within sight of launch pads. Some have nested in launch towers. The Indian River Chapter of the Audubon Society has for several years counted some 200 varieties of birds in Brevard County, including part of the Spaceport, which is more than were tallied by other chapters. Brevard led the nation in this competition for many years. At least 90 species frequent the Center. The local Audubon Society identified bald eagles, ospreys, hawks and vultures along with sparrows, owls, ibis, curlew, plover, terns, warblers, woodpeckers, doves, quail and other birds.

This is the unique environment of almost virgin wild land contrasting sharply with Space Age facilities serving the needs of the national program today and in the future. Yet it was just a few miles away, on Cape Kennedy, that Dr. Debus and his small team launched the first U.S. earth satellite, Explorer I, January 31, 1958; the first U.S. astronaut, Alan Shepard, May 5, 1961, and accomplished other significant "firsts" in the embryonic space program between those two events.

The accelerated momentum of space technology may be measured by the size of the first satellite, which weighed 30 pounds, and the November 1967 launch of a Saturn V vehicle which placed a mass of 285,000 pounds in near Earth orbit. Though long silent, Explorer I continues its journey through space while beneath it, men, money and creative imagination have established a national resource in the Spaceport that has no counterpart on Earth.



This drawing shows Dr. Debus' concept of a mobile transporter for the assembled space vehicle (later changed from a horizontal to a vertical mode).

II

The Mobile Concept

FOUR years of herculean toil by architects, engineers and construction workers—7,000 at peak employment in 1965—plus $800,000,000 provided by succeeding Congresses transformed north Merritt Island marshes into the bustling launch base for heavy space vehicles.

Construction of the large building in which Apollo spacecraft would be prepared for launch began August 17, 1962, and the first technical units occupied the structure in September 1964. On November 5, 1962 giant dredges moved into the Banana River to open a new barge canal to connect the Spaceport with the ocean access lock at Port Canaveral. Ground was broken August 20, 1963 for the enormous Vehicle Assembly Building, the site for which had been prepared by pouring in dredged fill from the Banana River. In the course of dredging operations, well-preserved bones of prehistoric mammoths and other animals were turned up and became prized mementos of the Corps of Engineers which supervised the construction for NASA.

The first test of the launch facilities with a specially built Saturn V rocket, complete except for rocket engines, occurred May 25, 1966, five years to the day after President Kennedy called for a national effort to land men on the Moon and return them to Earth in this decade. By late 1966, flight stages of the Apollo/Saturn 501 configuration began to arrive for processing and mating in anticipation of the first launch of the largest U.S. space rocket.

In retrospect, the decision to build the Spaceport stemmed from the establishment of NASA October 1, 1958, the agency which was charged with exploring outer space for peaceful purposes. Both events were influenced by the historic achievement of the Soviet Union in the successful launching of Sputnik, Earth's first artificial satellite, October 4, 1957.

Before the advent of NASA, the U.S. Army and the U.S. Air Force employed military booster rockets for early space missions in 1958. Until NASA was prepared to assume the leadership, similar missions were flown by the military services in 1959 and 1960 with NASA appearing

as co-sponsor of scientific experiments. None of these rocket systems compared with the Soviet boosters in thrust power. This may be translated into weight lifting capability or the measure of how many pounds of useful payload can be injected into Earth orbit which requires a velocity of 17,500 miles per hour. Consequently, in size at least, the early Explorer satellites and Pioneer moon probes of the American program fell far short of Russian spacecraft. From the start of their program, the Soviets could fly dogs in roomy, life-support equipped Sputniks weighing more than 1,100 pounds. The first U.S. satellite in the Spring of 1958 weighed little more than 30 pounds, or about the weight of a medium size dog.

But the promise of the future was already in the making. The Army team at Redstone Arsenal, commanded by Major General J. B. Medaris, initiated development in August 1958, of a super booster with modest financing provided by the Advanced Research Projects Agency of the Department of Defense. The purpose was to demonstrate the feasibility of clustering existing rocket engines derived from the military programs in a single booster capable of developing 1,000,000 pounds thrust at liftoff. It was called Saturn.

Earlier, the Army had put together a recommended national space program utilizing such available rockets as the Redstone, Jupiter and Atlas, envisaging the later availability of Saturn, stretching over a 15-year period and culminating with establishment of a manned outpost on the Moon. Titled Project Horizon, the two-volume proposal was regarded as a highly sensitive item in Defense. The Air Force submitted a competitive program.

With the decision to place the responsibility for conduct of the space program in a new civilian agency, NASA, some of the Army concepts found expression in the use which NASA made of the Redstone, Jupiter, Juno and Atlas vehicles and the agency's decision to proceed with the Saturn development.

In September 1959, President Dwight D. Eisenhower published an Executive Order transferring to NASA the Army's missile development group and the facilities they occupied at Redstone Arsenal and Cape Kennedy. NASA acquired the von Braun team of 5,000 civil servants, including its Missile Firing Laboratory directed by Dr. Debus. The transfer included $100,000,000 worth of laboratories, test stands, shops, equipment and office buildings. The Army's launch complexes and offices at Cape Kennedy were also transferred to the new agency. Dr. von Braun was appointed director of the NASA installation at Huntsville and placed in charge of developing heavy space vehicles. The Saturn booster, a cluster of eight engines and fuel tanks like those installed in Redstone and Jupiter rockets, successfully passed static firing tests in 1960, producing in its initial version a thrust of 1,200,000 pounds.

The Soviet Union scored another sensational first April 12, 1961 by

launching Cosmonaut Yuri Gagarin, the first man to orbit Earth. President John F. Kennedy asked NASA to formulate a program in which the United States might expect to overtake and pull ahead of the Soviet Union. NASA replied to the President by recommending the manned assault on the Moon in this decade. The National Aeronautics and Space Council, advisory to the President, supported the NASA proposal under the chairmanship of the then Vice President, Lyndon B. Johnson, who played a major role in steering through the Congress the Space Act of 1958. President Kennedy accepted the concept and made it a national goal with the support of the Congress.

Alternate methods of accomplishing the lunar landing were considered and the one selected became known as the Apollo program. It required the landing of two astronauts on the Moon in one spacecraft while a third astronaut orbited the Moon in the Apollo command module, awaiting his companions who would rendezvous with his craft after the initial exploration was completed. Then the trio would return to Earth. This basic decision fixed the size and weight requirements for the booster system essential to the task.

The Marshall Space Flight Center undertook to design the rocket, later to be called Saturn V, which would be five times more powerful than the early Saturns. Top-flight companies in the aerospace industry were brought into the undertaking by competitively awarded contracts. The Boeing Company undertook to fabricate the 7,500,000 pounds thrust booster, or first stage, employing five engines to be developed by the Rocketdyne Division of North American Rockwell, each generating 1,500,000 pounds thrust — about the same proportions as the total power developed by eight engines of Saturn I. North American was selected to fabricate the 1,000,000 pounds thrust second stage fueled with liquid hydrogen. The first stage would burn conventional kerosene. Douglas Aircraft Company won the competition to build the third stage developing 200,000 pounds thrust with liquid hydrogen. The same stage would also serve as the second stage of Saturn I for which Chrysler Corporation provided the clustered engine booster.

The Manned Spacecraft Center completed the competitive selection of spacecraft builders. North American was selected to build the Apollo spacecraft which would be essentially the same for both Saturn I and Saturn V missions. Grumman Aviation was chosen to build the lunar module — the spacecraft which would transport the astronauts to and from the Apollo and touch down on the Moon. Massachusetts Institute of Technology, supported by the AC Electronics Division of General Motors Corporation, was selected to furnish the spacecraft guidance system. General Electric Corporation won the competition to design automatic checkout equipment for the Apollo and lunar modules.

The Marshall Center also chose International Business Machines to

provide the guidance system for both Saturns, containing electronic controls which would steer the booster in flight and correct its trajectory to attain the pre-selected orbital path even if one engine of the booster failed after liftoff. This contingency was later deliberately programmed in a Saturn flight and the system worked perfectly.

While these multi-billion dollar contracts were placed by NASA, the Kennedy Space Center undertook the job of designing the launch facilities. Two of the complexes at the north end of Cape Kennedy, identified as Complex 34 and Complex 37, were completed by NASA although 34 had been initiated by the Army while its Missile Command executed the original Saturn project for the Department of Defense. They were, at the time of their completion, the biggest launch complexes in the Free World. But they would be dwarfed by the facilities required for the Saturn V vehicles.

Dr. Debus gave his engineers and planners the signal to proceed with the design of the Spaceport in March 1961. His original pencil sketches provided the concepts for structures as unusual in their own right as the spacecraft which can transport men to and from the Moon or the huge launch vehicles required to propel them. Neither the spacecraft, nor the booster rockets, nor the launch facilities existed anywhere when the Congress funded the early phases of the lunar program in 1961 and 1962.

Several fundamental considerations guided the master planning for the Spaceport:

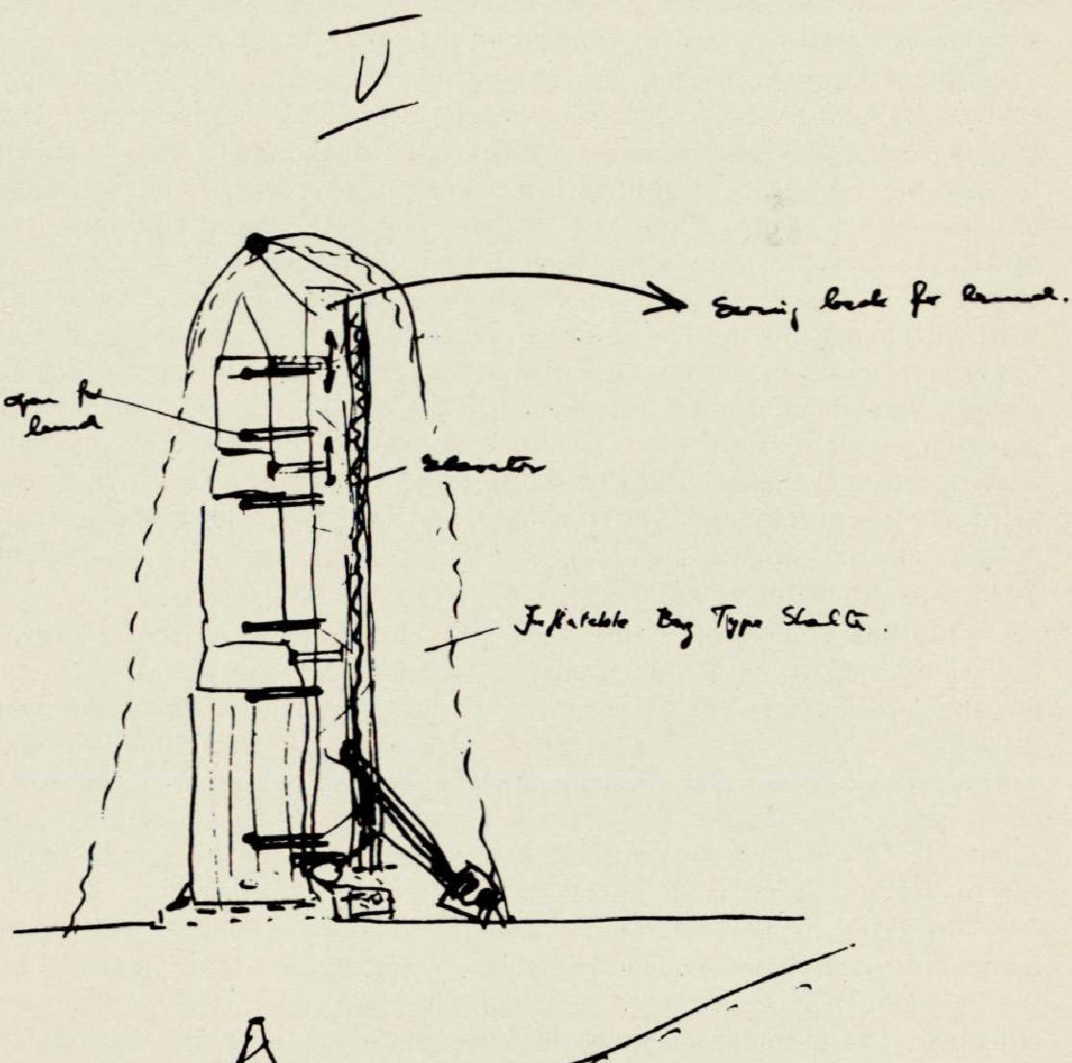
—only those activities essential to the checkout, mating, erection and launch of the Apollo/Saturn V would be located at the launch complex.

—all supporting activities, plus those directly involved in pre-mate testing of the Apollo and lunar module spacecraft, would be housed five miles south of the launch complex in what would be called the Industrial Area.

—NASA would help finance the construction of a new lock at Port Canaveral, linking the Indian and Banana Rivers with the Atlantic Ocean, permitting ocean-going barges to carry the Saturn V stages by water from the points of fabrication and test on the West Coast, or in Mississippi or Alabama directly to the launch complex. A channel would be dredged in the shallow waters of the Banana River to accommodate barges plying between the port and the launch area.

—About one-third of the total land and water area incorporated within the NASA installation extending north almost to New Smyrna Beach would be reserved for future launch sites required either by NASA or the Defense Department.

New and bold thinking went into the design of ground facilities by



In this drawing Dr. Debus visualized the Apollo/Saturn V at the launch site. The National Civil Service League presented its Career Service Award to Dr. Debus for his lead role in creating Complex 39.

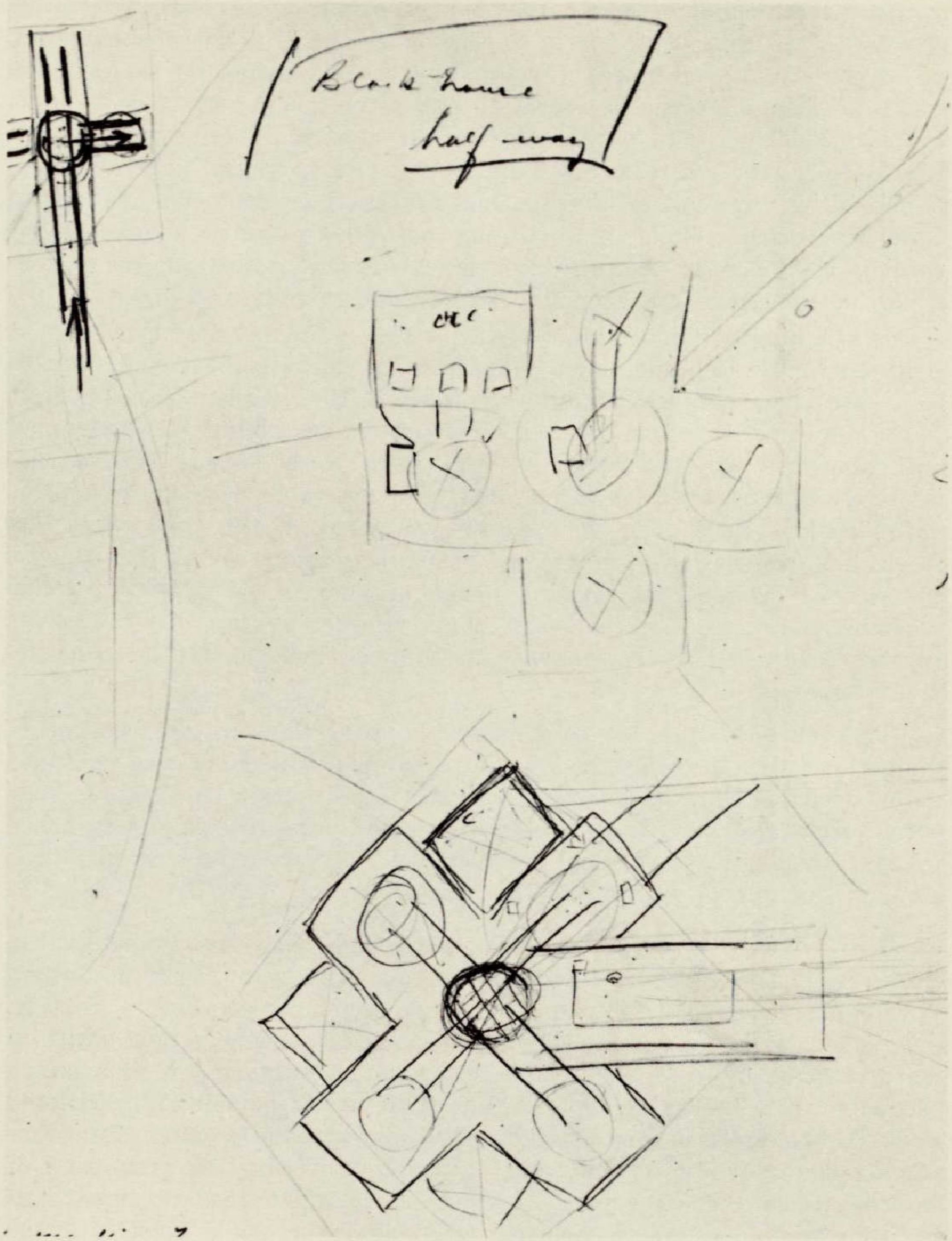
Government and industry engineers who realized that the Spaceport must serve the needs of the space program for many years. They understood that after initial test flights the Saturn V system would become operational in much the same sense as modern jet aircraft. They appreciated that the size, complexity and cost of these space transportation systems demanded a radical change in the operational mode.

Since the first rocket, a combination of a captured V-2 with an early U.S. Army vehicle, roared off Cape Kennedy's sands in July 1950, launch techniques had remained essentially unchanged. They provided for the assembly, pre-flight test and erection of rockets and spacecraft on the launch pads. These are stable, concrete bases equipped with service towers, or gantries, which permit technicians to work on the vehicle in the vertical launch position by means of access elevators and work platforms not unlike painters' scaffolding on a much larger scale. Umbilical masts or towers are utilized as the means to carry fuel and power lines from ground sources into the vehicle. Nearby blockhouses function as control centers for launch crews and protect their members during the hazardous phases of testing and launching. They are heavily reinforced concrete and steel shelters as they must be since a fueled rocket, on the launch pad, represents potential explosive equivalency depending upon the amount and kind of propellants it carries.

This potential danger influenced the construction of the blastproof type blockhouses on Cape Kennedy which were located only a few hundred yards from the firing pads. Greater separation distances were infeasible in the state of electronics technology at the time — signal degradation between the vehicle and the control systems in the blockhouse left no choice but to keep the crews close to the launch vehicles. Likewise, the hazard prevented the presence of other personnel within the prescribed safety zone surrounding flight ready rockets.

The fixed concept of launch preparations — assembly, testing and launch from the same pad or complex — tied up the total facility from the moment the first stage reached the pad until the vehicle was launched. The painstaking work of assembling and checking mechanical, electrical, pneumatic and electronic systems and components within the rocket stages, the spacecraft and ground support systems required much time and effort. Preparations for a Delta launch may extend over 60 days, for a Saturn I to 120 days and, in the case of one NASA experimental vehicle, 14 months. Hence, the number of rockets that can be launched from a given complex in the course of a year is relatively limited. This is especially true in the research and development period before the vehicle becomes operational through successive tests. It is in this breaking-in period that the functional systems and their interrelationships in a new vehicle pose numerous problems. Preparation or "pad time" relates to the size and complexity of the vehicles.

During the stay time on the launch complex, the rockets are exposed



Dr. Debus conceived of a building for vehicle assembly with four separate bays, each accessible from a centrally located turntable. In 1961, when these were prepared, NASA had not yet determined the most practical mode of transportation between the assembly area and the launch site.

to storms which sometimes interrupt preparations, and the corrosive effects of the salt atmosphere. For some reason the salt concentration is heavier at Cape Kennedy than at any other location on the Atlantic coast. Then, too, Florida lies within a hurricane target area. Almost without exception in recent years, between the months of June and October, Florida's East Coast comes under hurricane alert several times from storms brewing in the South Atlantic, the Caribbean Sea or the Gulf of Mexico. Winds of 100 miles per hour velocity have been recorded on the Cape Kennedy service structures although, in modern times, no hurricane has ever struck the Cape in full fury.

When hurricanes threaten, NASA's smaller launch vehicles such as Delta or Atlas Centaur must sometimes be disassembled and trucked back into large hangars for safekeeping lest they sustain damage from flying objects or topple over if the protecting launch tower cannot withstand the wind. Massive as they seem to be, space vehicles are relatively thin-skinned and fuel and oxidizer tanks can be punctured quite easily. The launch vehicles are returned to the pads when the storm has passed. It is inherent in pre-launch preparations that if vital connections between vehicle and blockhouse have been severed for disassembly purposes, the crew must begin all over again when the rocket returns to its pad. Storms have exacted just such substantial penalties many times.

To reduce this problem to manageable proportions for heavy vehicles, the service structure designed by NASA for Complex 37 was equipped with hurricane shutters or gates. In 1964 a fully assembled Saturn rode out a hurricane safely within the structure and was subsequently launched without incident. Since then the Complex 34 service tower has been similarly equipped with protective gates.

His experience in these predicaments convinced Dr. Debus that a more efficient method must be found to cope with vehicles of the Saturn V category. His early sketches envisioned a mobile concept — that is, the rocket would be assembled and checked out with the spacecraft in the protective environment of a building, and transferred to the launch pad only when almost ready for flight. This would permit uninterrupted work in the erection and checkout process, provide greater assurance against countdown problems, and materially increase the frequency of launches from the same pad. Further, he reasoned that the means of transporting the vehicle to the pad could again be called upon in emergency to carry it back inside its hangar, all connections intact, and return it to the pad when the storm was over.

These were the basic guidelines he provided to Rocco A. Petrone and other planners as they set to work to examine the alternatives and work out solutions for the unprecedented facilities required to achieve these results.

III

Assembling The Vehicles

TO meet the unusual requirements for Launch Complex 39, home of the Apollo/Saturn V space vehicles, required ingenious engineering solutions. Architectural Forum described the undertaking as "one of the most awesome construction jobs ever attempted by earthbound men."

The principal features of the complex were to include:

—a hangar big enough to house the Saturn V rockets, each standing 363 feet tall

—a mobile launch base on which the rockets would be assembled and from which they would be launched

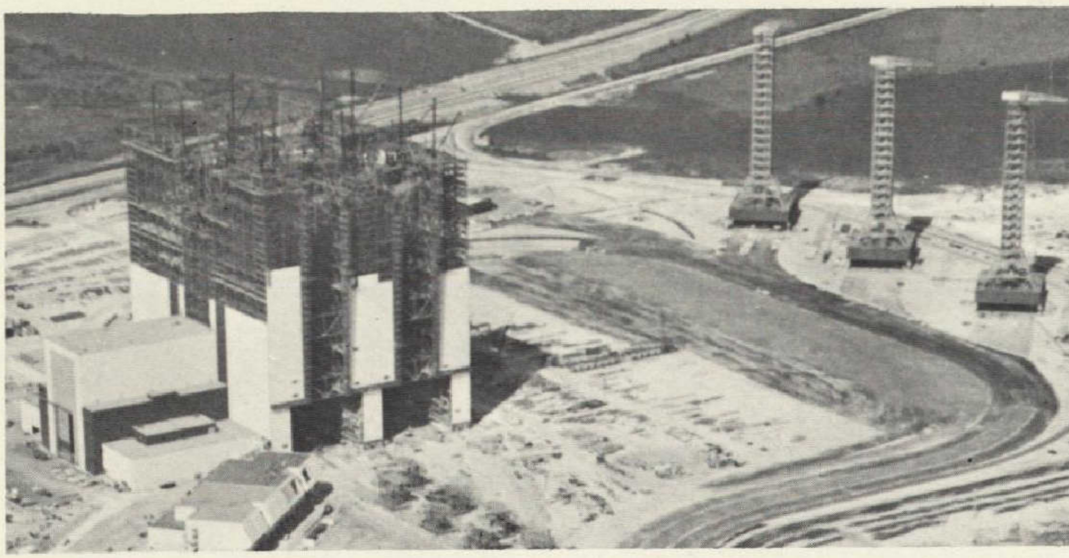
—a method of transporting rockets and launchers weighing 12,000,000 pounds a distance of 3.5 miles to the firing site

—a service structure enabling technicians to complete preparations of the Apollo spacecraft at the launch site

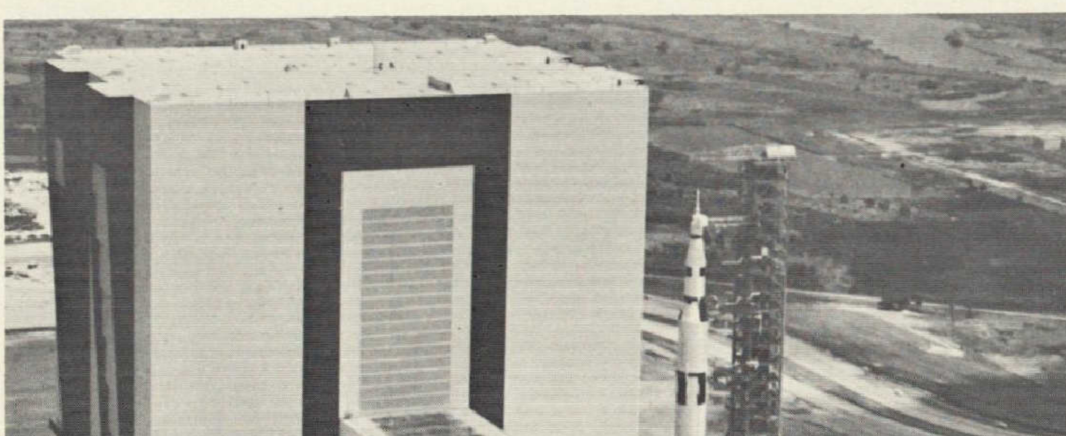
—a control center from which all of these operations could be monitored and controlled.

None of these existed. But they were essential for launching the lunar excursion vehicles to execute the Apollo program approved by the Congress at the request of President Kennedy. As the resources to carry out the projects were marshalled, NASA became the planner as well as the eventual user while Army's Corps of Engineers acted for the space agency in awarding brick-and-mortar construction contracts and supervising the builders. The Corps activated a new facility agency known as the Canaveral District for the NASA undertaking as well as for military construction projects on Cape Kennedy Air Force Station.

The Florida East Coast Railroad built a new causeway across the Indian River linking the Spaceport with the mainland in order to move freight trains directly to the construction sites. The Government laid trackage on the NASA installation and extended the line to carry materials directly to Cape Kennedy as well.



Upper photo is part of Complex 39 while under construction in March 1965. Three Mobile Launchers, then being assembled, are at right, Vehicle Assembly Building in left foreground. Below, the same area today. An Apollo/Saturn V space vehicle is being moved from the building to the launch site three miles away.



Much of the structural steel was transported by truck from Tampa, on Florida's West Coast, where it was received from northern mills, specially treated against corrosion, and then delivered to the Space Center.

By November 1962, sufficient planning data had been collected from vehicle and spacecraft design centers so that the joint architectural design team of Urbahn, Roberts, Seelye and Moran could begin work on detailed plans for the hangar. Since the Apollo/Saturn V was by all measures the most powerful and largest space vehicle in the U.S. program, the structure to accommodate it turned out to be one of the world's largest in terms of volume. Covering eight acres, the Vehicle Assembly Building encloses 129,000,000 cubic feet, almost the equivalent of the combined volumes of two of the largest buildings of modern times — the Pentagon in Washington, D.C., with 77,000,000 cubic feet and the Merchandise Mart in Chicago, Ill., with 56,000,000 cubic feet. During a visit after the building was finished, cowboy movie star Roy Rogers commented that "you could sure store a lot of hay in there!"

Early sketches by Dr. Debus suggested a cruciform shape for the building. Next it was proposed to array the checkout bays, in which rocket stages are tested in vertical position, in a single row which would have resulted in a narrow, slablike skyscraper. Finally, NASA chose a back-to-back arrangement with a transfer aisle between rows of checkout and assembly bays. The resulting box-type structure, rectangular in shape, was more economical and stiffer, and capable of withstanding hurricane force winds up to 125 miles per hour.

The designer's task was further complicated by the need to provide clear working space to manipulate stages as big as the first, or booster, stage measuring 138 feet in length and 33 feet in diameter as well as to stack stage upon stage until the vehicle reached full height of 364 feet. A bridge-like truss system of braced multiple towers was selected which combined optimum stiffness with flexibility of layout. More assembly bays can be added to the building in the event future space missions require them.

Clearing and filling operations began in November 1962, with the removal from the site of unsuitable material. After clearing and grubbing, the average height of the area was only 1.5 feet above sea level. Hydraulic fill dredged from the Banana River channel and a turning basin for ocean barges transporting rocket stages to the complex raised the level to almost seven feet by July 1963. In all, 1,500,000 cubic yards of soil from the river bottom were pumped to the eight-acre VAB site.

Providing a firm foundation for the massive proportions of the building was one of the early challenges. Pile testing disclosed a three-foot limestone shelf at a depth of 118 feet. Below that silt was encountered

until limestone bedrock was located at 160 feet under the surface. Some core borings turned up petrified wood specimens which under carbon testing were found to be 25,000 years old.

It was decided to support the great weight upon open end steel pipe pilings, 16 inches in diameter and three-eighths of an inch thick, driving each pile to bearing on the rock formation. Blount Bros., the contractor, required six months, beginning in May 1963, to drive 4,225 steel piles through the upper limestone layer to bedrock. This was the equivalent of 128 miles of steel. Because the piling penetrated a salty chemical solution, there was a tendency to produce electrolysis. Cathodic protection had to be applied to neutralize the current; otherwise, the foundation would have corroded. Until then the VAB could lay claim to being the world's largest wet cell battery.

Wind tunnel tests confirmed that if conventional building methods were employed, the structure might blow over in a hurricane due to its size and shape. To anchor it securely, 30,000 cubic yards of concrete were poured for pile caps and floor slab.

The joint firm of Morrison-Knudson Co., Perini Corp., and Paul Hardeman, Inc., was selected by the Corps of Engineers to build the VAB proper. American Bridge Division of U.S. Steel became the subcontractor for steel erection and started work in January 1964. Morrison-Knudson, Perini and Hardeman built the floors and installed roofing and siding. There are 56,000 tons of structural steel in the framework and more than 1,000,000 square feet of insulated aluminum siding in the outer skin. The building was structurally completed in June 1965. A large beam, painted white for the purpose, had been autographed by construction workers, NASA and Corps of Engineers employees, and was hoisted into place at the traditional topping out ceremony.

Looming above the flat terrain of the Spaceport, the building does not impress visitors as they approach it by auto since there is no other structure which would provide a comparison. It is not until the visitor enters the transfer aisle and looks up to the supporting beams under the roof that he grasps the enormity of the VAB. Overall, it is 716 feet long, twice the length of a football gridiron, and 526 feet high, only 29 feet less than the Washington Monument.

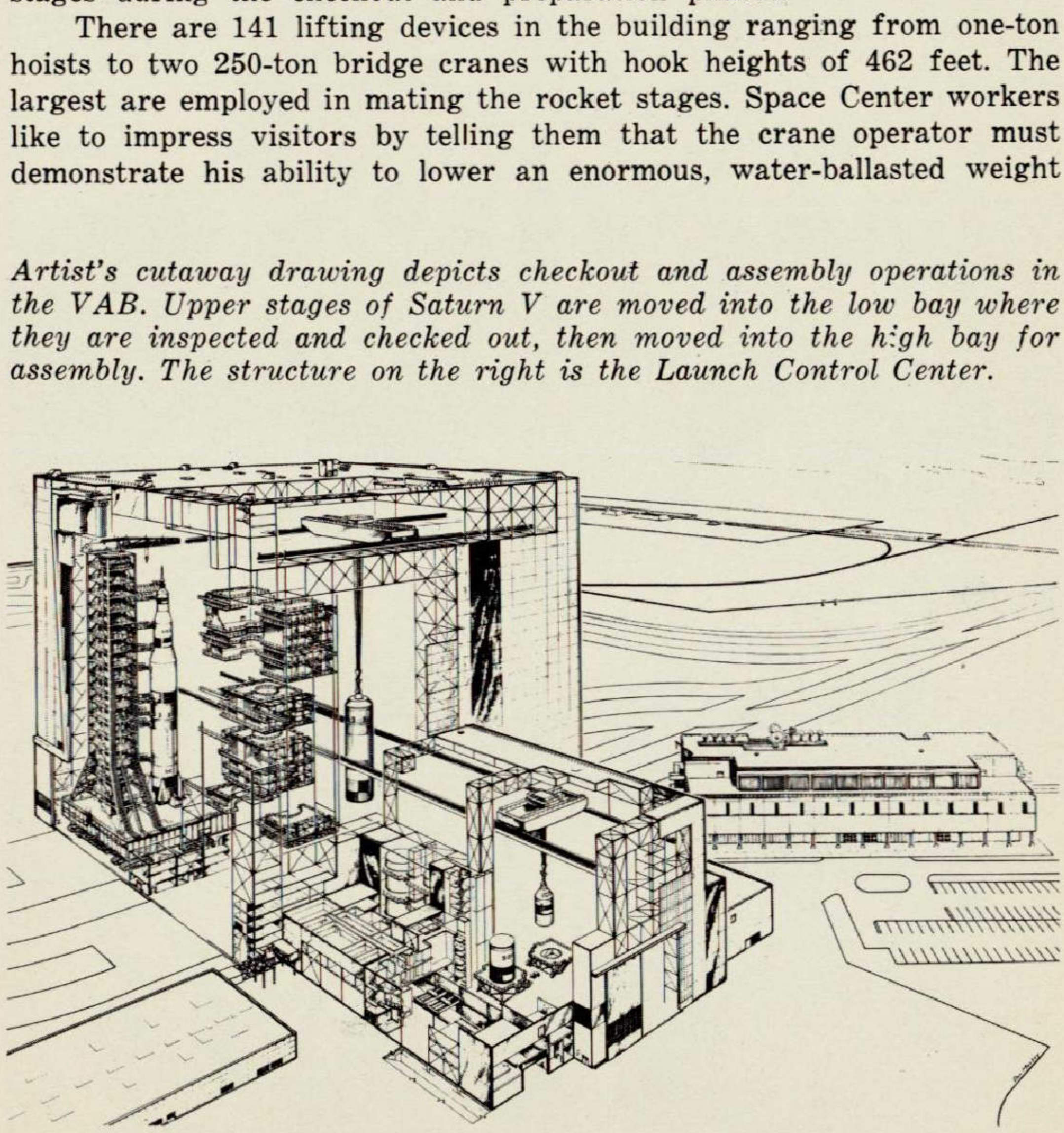
There are two main sections. The high bay portion is 441 feet long and 517 feet wide and contains four bays, each capable of housing the fully configured Apollo/Saturn V or any other space vehicle of like dimensions. The low bay portion is 275 feet long, 211 feet high and 440 feet wide, and contains eight stage preparation and checkout cells for the second and third stages of the Saturn V. Each cell is a structural steel assembly equipped with work platforms that open to receive the

stages and then enclose them. Each cell has mechanical and electrical systems which permit simulation of stage interfaces and operations with other stages and the instrument unit or guidance system.

Three of the high bays are equipped for Apollo/Saturn V vehicles while the fourth has been reserved for possible future configurations such as a Saturn I vehicle with strapped-on solid propellant booster rockets to increase liftoff thrust, or a modification of the Saturn V. Any rocket that can be fitted within the high bay doors could conceivably be prepared for launch in the building. Within each bay is a clear center area 494 feet in height. Enclosed platforms as large as three-story buildings are installed on the sides of each bay. They can be adjusted up and down, or moved in and out like suspended file drawers, mating to form buildings within the building, and encircling the Saturn V stages during the checkout and preparation phases.

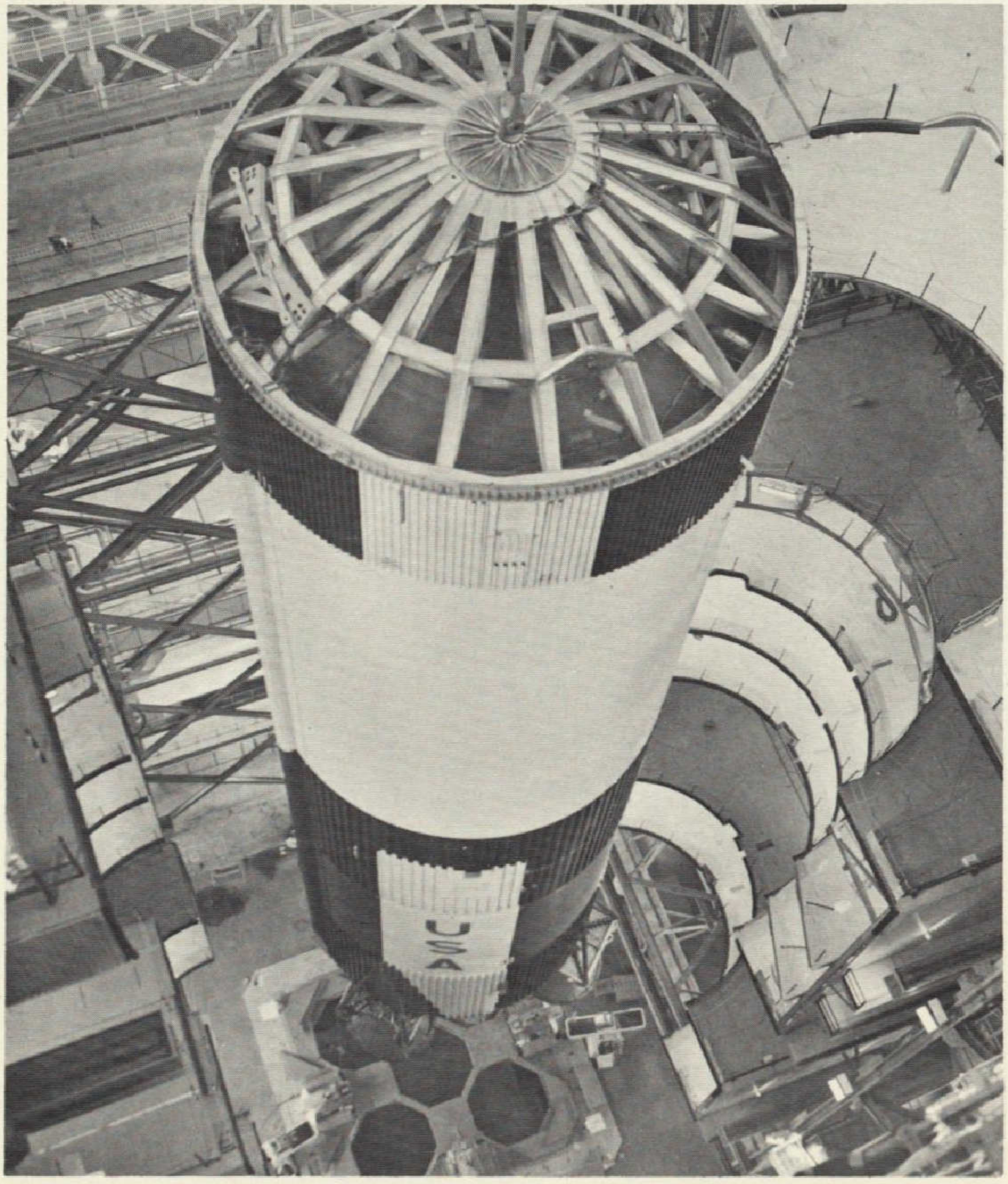
There are 141 lifting devices in the building ranging from one-ton hoists to two 250-ton bridge cranes with hook heights of 462 feet. The largest are employed in mating the rocket stages. Space Center workers like to impress visitors by telling them that the crane operator must demonstrate his ability to lower an enormous, water-ballasted weight

Artist's cutaway drawing depicts checkout and assembly operations in the VAB. Upper stages of Saturn V are moved into the low bay where they are inspected and checked out, then moved into the high bay for assembly. The structure on the right is the Launch Control Center.



upon a raw egg without cracking its shell. Electronic controls permit operators of the biggest cranes to move them in all directions at speeds as low as one-tenth foot per minute. While movement speed for cranes of this size is one and one-half feet per minute, the infinitely slower speed is required for mating Saturn V stages. Mating holes of the stages

Precision control to the nth degree is required as 250-ton capacity crane gently lowers the Saturn V first stage to Mobile Launcher deck.



are of such close tolerance and must be so closely parallel and radially oriented that feeler gauges are used to measure the tolerances. By means of dial readings in his cab, the crane operator can detect 1/128th of an inch movement.

Gigantic doors form the outer wall of each high bay in the shape of an inverted T. Each is 149 feet wide and 113 feet high at the base, then narrows to a width of 71 feet at the maximum height of 456 feet. The lower portion is closed with four leaves sliding horizontally. Above the 114-foot level, the door consists of seven leaves operated vertically. Each leaf is 71 feet wide and 50 feet high and weighs between 52 and 73 tons. Each of the four high bay doors is big enough to admit the Statue of Liberty or Chicago's Wrigley Tower.

To prevent condensation and fogging within the structure — clouds might form in so vast a space — a gravity ventilation system effects a complete change of air every hour through 125 ventilators placed on the roof. Selected parts of the building, however, are supplied cooled and conditioned air. A utility annex houses air conditioning, water and electrical equipment — four 25,000-ton capacity water chilling units maintain the desired temperature for 800,000 square feet of floor area including the work platforms of the high bays and offices.

Floors of office space rise tier upon tier alongside the high bays and are serviced by 16 high speed elevators traveling at a maximum rate of 700 feet per minute. Almost 3,000 employees of stage contractors and Government personnel occupy these areas. Each contractor occupies space convenient to his stage — Boeing personnel occupy floors next to the first stage. Above them are North American Rockwell personnel concerned with the second stage, then McDonnell-Douglas personnel with the third stage, IBM technicians near their instrument unit, more North American personnel above them and adjacent to the Apollo spacecraft, and Grumman employees occupying offices near the lunar module.

Connected with the VAB on the southeast by a hallway is the Launch Control Center. Max Urbahn, who headed the design team, remarked that the Vehicle Assembly Building "is not so much a building to house a moon rocket as a machine to build a moon craft. The Launch Control Center that monitors and tests every component that goes into an Apollo vehicle is not so much a building as an almost living brain."

The four-story Control Center differs completely in shape and construction from the squat, conical blockhouses that dot Cape Kennedy. There the launch crews must be protected against hazard while operating only a few hundred yards from the fully fueled rockets. Advances in digital data transmission and handling since the launch complexes

were installed on the Cape made it possible to install in the Control Center of the Spaceport computers and consoles connected directly with launch vehicles and spacecraft while undergoing preparations in the VAB, and when they have been subsequently transferred to the launch site 3.5 miles to the East near the ocean shore. From firing rooms in the Control Center, launch crews can monitor and control all of the multiple technical operations performed in checking out, mating, testing, fueling and launching these huge space transportation systems.

In complex functional systems, the rockets and their cargo are many times removed from the smaller and much less sophisticated vehicles employed for NASA's unmanned scientific missions. Only the availability of modern computers and automation techniques have made it feasible to design, fabricate, test and launch the Apollo/Saturn V. The countdown has been automated to unprecedented degree because of the myriad of functions which must be verified and measured simultaneously.

Two separate, automated computer systems are employed. The ACE, or Automatic Checkout Equipment designed and operated by General Electric Co., is used for the Apollo spacecraft. The Saturn Ground Computer System is used for the first, second, and third stages of the launch vehicle. While the ACE equipment is remotely located in the Industrial Area, the Launch Control Center houses the heart of the Saturn Ground Computers. This system employs two RCA 110A computers as its brain, one in the Center, and the other in the base of the mobile launcher.

Both automated systems permit a small staff of engineers to monitor and control the data. ACE engineers can monitor and control more than 24,000 samples of spacecraft test data per second. The measuring program for the Saturn V launch vehicle checks 2,728 discrete functions or systems, providing to the designers and launch team verification that critical components operated properly during pre-launch tests and the launch itself.

In the Control Center too, NASA requires the same contractor who builds the stage to man the consoles controlling its preparation for launch. Thus, Boeing employees monitor the first stage, North American Rockwell the second stage, McDonnell-Douglas the third stage, IBM the instrument unit, North American the Apollo spacecraft, and Grumman the lunar module, under the alert supervision of Government test conductors.

While launch crews in Cape Kennedy blockhouses can view the launch only via closed circuit television or through periscopes, the crews launching Apollo/Saturn V can watch the rocket liftoff through huge windows placed in the east wall. Three firing rooms have been equipped, their

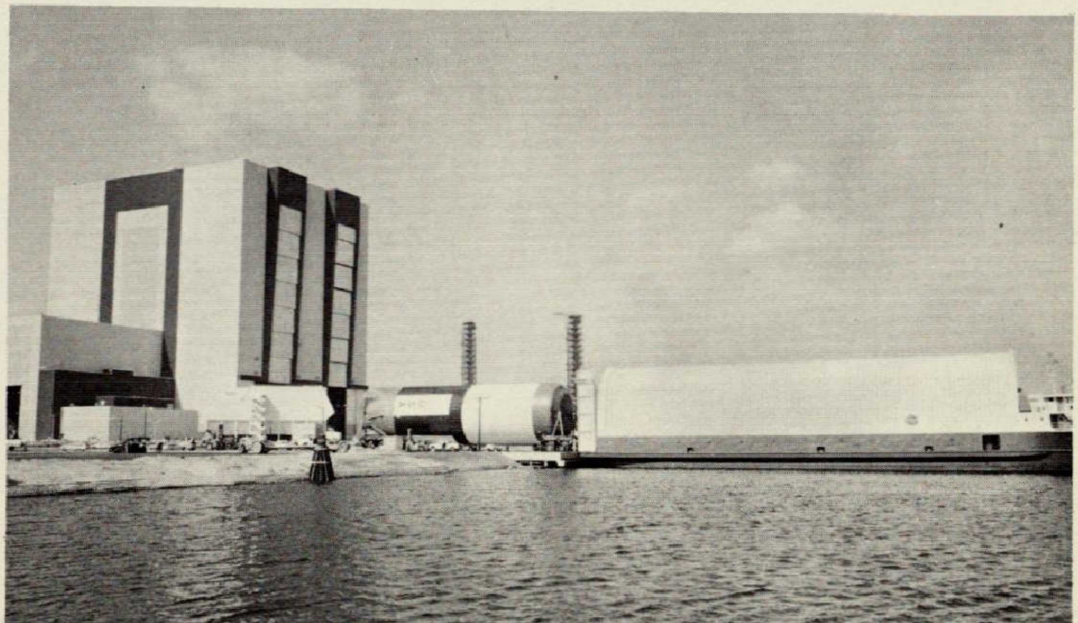
instruments connected with the high bays of the Vehicle Assembly Building. The use of the same instrumentation for pre-launch checkout in the VAB and for fueling and launch from the firing site assures uniform standards of measurement regardless of where the space vehicle is located at the time. The fourth firing room serves as a control center where the multiple tasks essential to preparing the Apollo/Saturn configurations are projected, work schedules are decided, and daily progress charted for the test conductors and supervisors.

Other facilities in the Control Center house the communications systems for Complex 39, including a closed circuit television network that permits operators in the firing room to view activities in remote hazardous areas, or to look directly at some component of the launch vehicle which may cause a problem. There are working areas for personnel engaged in telemetry data reduction and evaluation by which design and launch engineers determine just how the rocket and its intricate systems performed in the final countdown and flight.

Supporting contractors providing specialized services to the launch organization, such as Trans World Airlines, Bendix, Catalytic-Dow, Federal Electric and others occupy quarters in the low bay area of the VAB or the Control Center.

Immediately south of the Control Center is the Barge Terminal which consists of the access canal joining the Banana River on the east, a turning basin, dock, barge slips, and a materials handling area. The

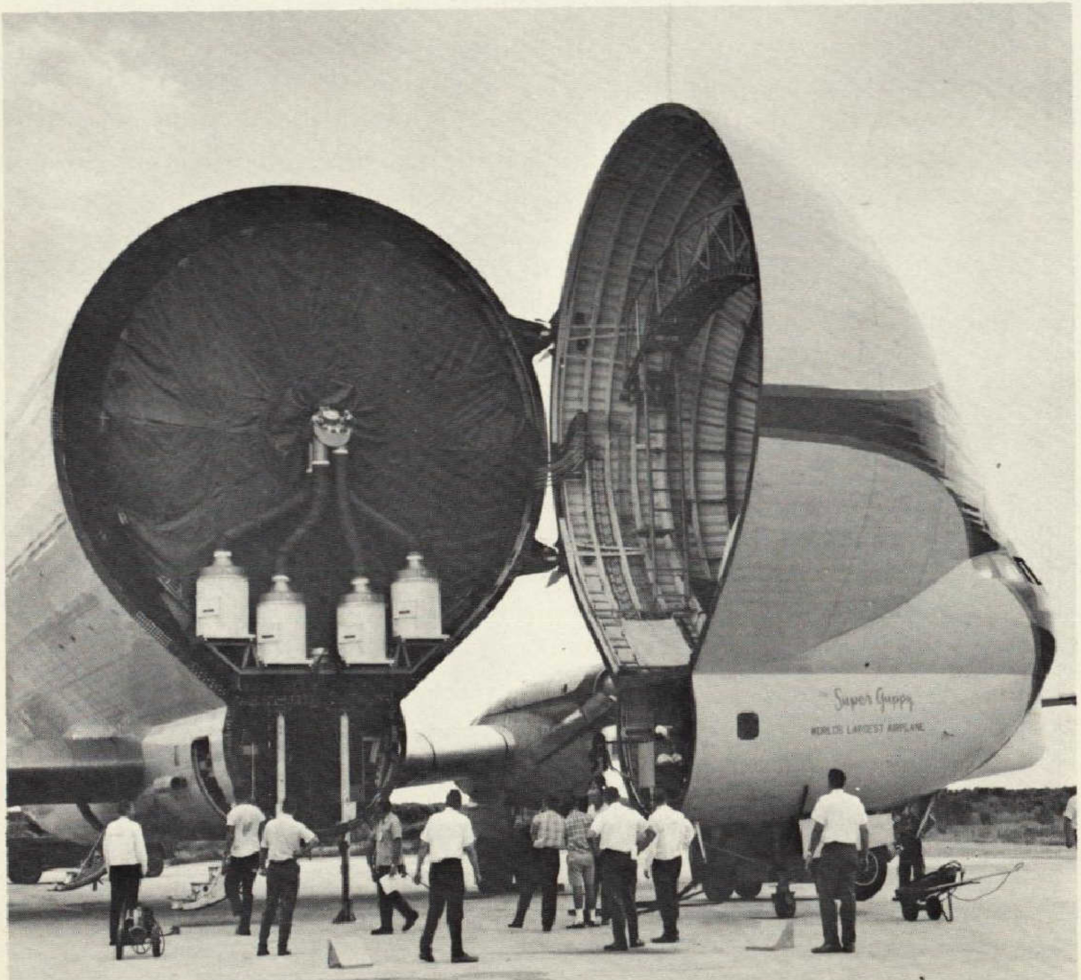
Saturn V first stage is off-loaded from sea-going barge at the VAB.



basin is 1,200 feet across and 10 feet deep. The larger rocket stages cannot be shipped by land because of their size. They reach the launch center on barges traversing the Gulf of Mexico, either from California, Mississippi or Alabama, thence around the tip of Florida through the Keys, up the Atlantic Coast to Port Canaveral, and into the Banana River enroute to the assembly area. The smaller stages and spacecraft arrive by air in a special cargo aircraft, called the "Guppy," remodeled to make room for oversized loads.

Here they are prepared for the moment of truth, the incredible act of launch when all the work of thousands of people in many locations finally reaches fruition.

Saturn V third, S-IVB stage, arrives at Cape Kennedy Air Force Station Skid Strip in Super Guppy, a conventional aircraft modified to make room for large space vehicle stages. Apollo spacecraft modules also arrive by aircraft.



IV

Hangar To Pad

AS the steel skeleton of the Vehicle Assembly Building rose out of the sand, other contractors — working directly for NASA — undertook the assembly, erection and equipping of mobile launchers which are the key to the new concept of operations. In essence they are moveable launch platforms with integral umbilical towers of such magnitude that they became the heaviest portable structures known to the Free World.

Three identical launchers were built for the three high bays of the VAB on which three Saturn V space vehicles could be prepared simultaneously for flight. Each launcher is 445 feet tall and weighs about 12,000,000 pounds. The two-story base, enclosed by battleship grey steel plates, covers half an acre. Within the base are computers linked with the computers in the firing room of the Launch Control Center and also connected with other launch related equipment.

Towering over the base is the red umbilical structure. It provides support for nine swing arms for direct access to the space vehicle, 17 work platforms and distribution lines for propellant, pneumatic, electrical and instrumentation systems.

Ingalls Iron Works of Birmingham, Alabama, began to erect the structural steel of the first launcher in July 1963, and topped out the third launcher in March 1965. When the first was topped by the installation of a 25-ton hammerhead crane, Ingalls arranged a luncheon under the launcher base for 300 hard-hatted construction workers whose on-time performance won the plaudits of the KSC Director. Then NASA and Ingalls officials and employees cheered as the crane surmounting the tower was smoothly hoisted into position.

Smith-Ernst of New York City performed electrical and mechanical installation projects concurrently as Ingalls built up the structures. Pacific Crane & Rigging Co. began the installation of ground support and miscellaneous equipment in June 1965. Brown Engineering Company

worked on design of the swing arms which were then fabricated by Hayes International. These are mechanical bridges, some of them 60 feet long, weighing from 35,000 to 52,000 pounds, by which launch technicians can enter the space vehicle at various levels. The topmost arm, 320 feet above the launch platform, is the access bridge by which Apollo astronauts enter and leave their spacecraft.

While the technology of swing arm operations was successfully demonstrated at Complexes 34 and 37 on Cape Kennedy, from which NASA launches Saturn I rockets, the swing arms at Complex 39 for Saturn V were much heavier and presented another difficult engineering problem. They must support propellant lines used in fueling all three stages as well as electrical and pneumatic feeds from the ground into the rocket. Four of the arms can be disconnected prior to launch, but five supply services that cannot be interrupted until the rocket actually begins its lift from the pad. Therefore, they must retract in from two to five seconds to avoid deflecting the giant space vehicle as it begins its ascent. Pneumatic systems pull back the arms which swing back against the umbilical tower.

All three mobile launchers were completed and in service by the Fall of 1968, permitting concurrent preparation of three Apollo/Saturn V vehicles in the Vehicle Assembly Building.

Giant holddown arms, whose name exactly describes their function, are positioned on the launcher surface to support and restrain the Saturn V. These arms hold the rocket during the first 8.9 seconds of ignition of its mighty engines while the computer beneath, communicating directly with the computer in the Launch Control Center, verifies the performance of each of the 1,500,000 pounds thrust power plants of the first stage. When all five engines reach full thrust, and only then, the computers release the holddown arms which retract and allow the rocket to rise.

Designing these mobile launch pads posed many problems since they must withstand the tremendous shock, heat and vibration which occurs when the engines ignite. Then, too, the launchers had to be designed so they could be picked up and moved not once but many times. Sensitive electronic and electrical equipment mounted in the base had to be protcted against damage during the months of checkout, monitoring servicing and launching the space vehicles. The launchers rest on 22-foot tall pedestals either at a parking area, while in the VAB high bays, or on the launch sites. A 45-foot square opening in the base vents the engine exhaust into a flame trench on the firing site.

The mobile launch platform houses a mechanical equipment room, an operations support room, communications and television equipment,

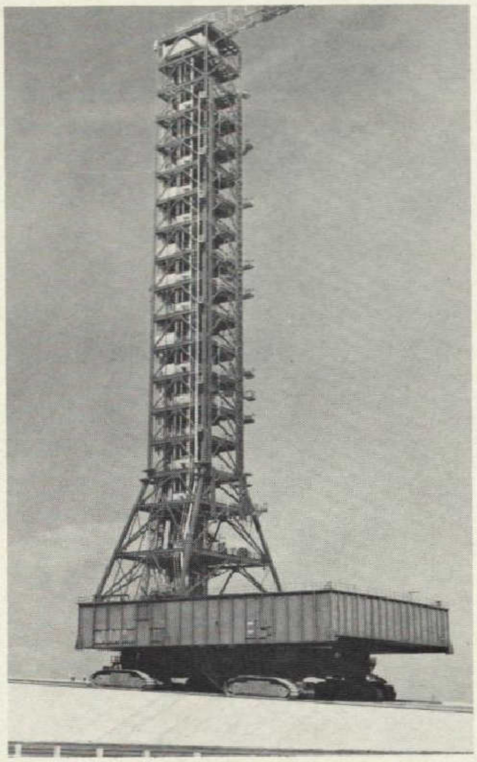
and other equipment compartments. Floors within the base are mounted on springs or shock isolators while the walls are lined with two inches of thermal and acoustical fiberglass insulation. Computers occupy cocoon-like compartments enclosed by one-inch thick steel plates lined with four inches of fiberglass. It was determined that the noise level within the compartments after the firing of Apollo 4 was 148 decibels compared with 172 decibels near the Saturn V engines. By comparison, a modern jet liner's engines create sound measured at 135 decibels. Digitally controlled equipment for propellants loading, operated remotely, is also housed in the launcher base.

Two high speed elevators, centrally positioned in the umbilical tower, transport launch technicians to and from the swing arms and 17 work platforms. These elevators can be programmed for emergency use by the astronauts at the launch site and can lower the Apollo crew to the launcher deck within 30 seconds.

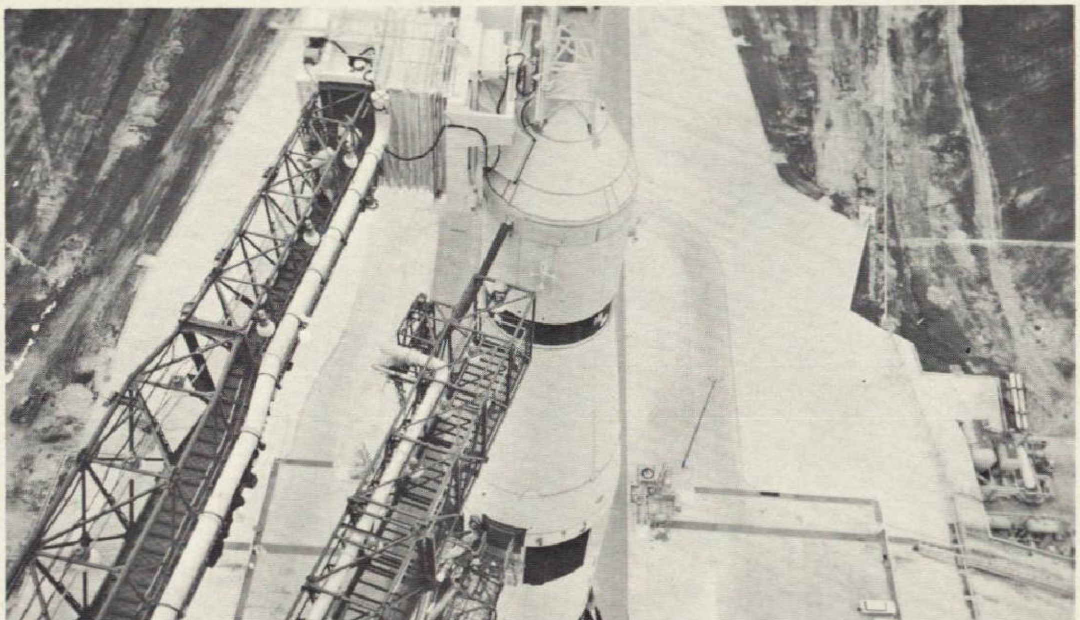
The scheme by which to transport launchers and assembled Saturn V vehicles was carefully explored by NASA engineers. A barge canal system was investigated. Models were tested in the Navy's David Taylor Model Basin on the Potomac near Washington, D.C. They revealed that hydrodynamic problems caused by a barge large enough to carry the rocket in upright position would be extremely difficult or costly to solve. Also, an elaborate launch pad would be needed.

Other potential solutions proved impractical, or in the case of a railroad, too costly for moving the tremendous loads involved. Pneumatic-tired transporters, ground effects machines, and other ideas were discarded. The final choice was a track-mounted crawler so big that after partial assembly at the plant of Marion Power Shovel Company, Marion, Ohio, it was taken apart in moveable sections, shipped to the launch center and there assembled. This solution was derived from the strip mining industry and involved the use of hydraulic power for jacking, leveling and steering.

The contract to build two crawlers was placed with Marion in 1963 and both machines were in service by early 1967. Each weighs approximately 6,000,000 pounds and can transport a mobile launcher with assembled Apollo/Saturn V vehicle at a speed of one mile per hour — the trip to the moon begins at a very slow pace. In event of hurricane alert, the crawler will remove launcher and rocket from the firing site, all connections intact, and carry both into the safety of the Vehicle Assembly Building to ride out the storm, then return them to the launch pad. Hurricane forecasts afford a minimum of 24 hours warning. In actual tests, it has been demonstrated that the transfer from pad to building can be achieved in less than 12 hours.



Right: Crawler moves Mobile Launcher up 5 per cent incline to Pad A during test run. Below: Swing arms provide electrical, pneumatic and fuel connections between ground support equipment and the space vehicle. Astronauts enter the Apollo Command Module through the top arm (left).

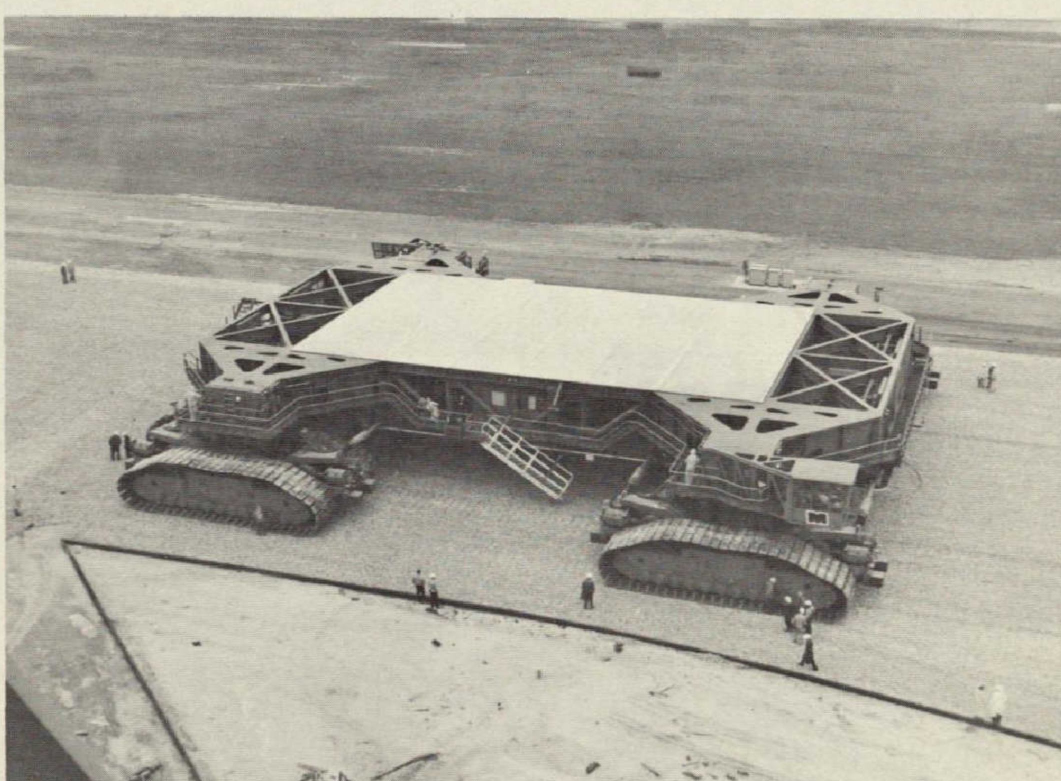


Dimensions of the crawler are in scale with the Paul Bunyanesque proportions of other Saturn V ground equipments. The platform atop the crawler is a little larger than a baseball diamond infield. Each tread in the ponderous tracks weighs about one ton. Yet the machine carries 12,000,000 pounds or more, maintains a level platform, and locates itself at the launch pad or in a high bay of the VAB within plus or minus two inches.

One sceptical journalist commented in 1965 that "it will never work." But the crawlers do work. They have transported the massive cargoes without difficulty, negotiating curves and climbing the 5- per cent slope to reach the surface of the launch pad. When Hurricane Alma boiled up the West Coast of Florida June 8, 1966, Dr. Debus seized the opportunity to test the concept to the full. He called in supervisors of the launch organization and on one hour's notice ordered them to return the Saturn V vehicle from the pad to the VAB bay.

They accomplished the task in 10 hours in driving rain and wind gusts up to 65 miles per hour, demonstrating that with the usual 24-hour hurricane notice, the mobile concept will work successfully. That initial

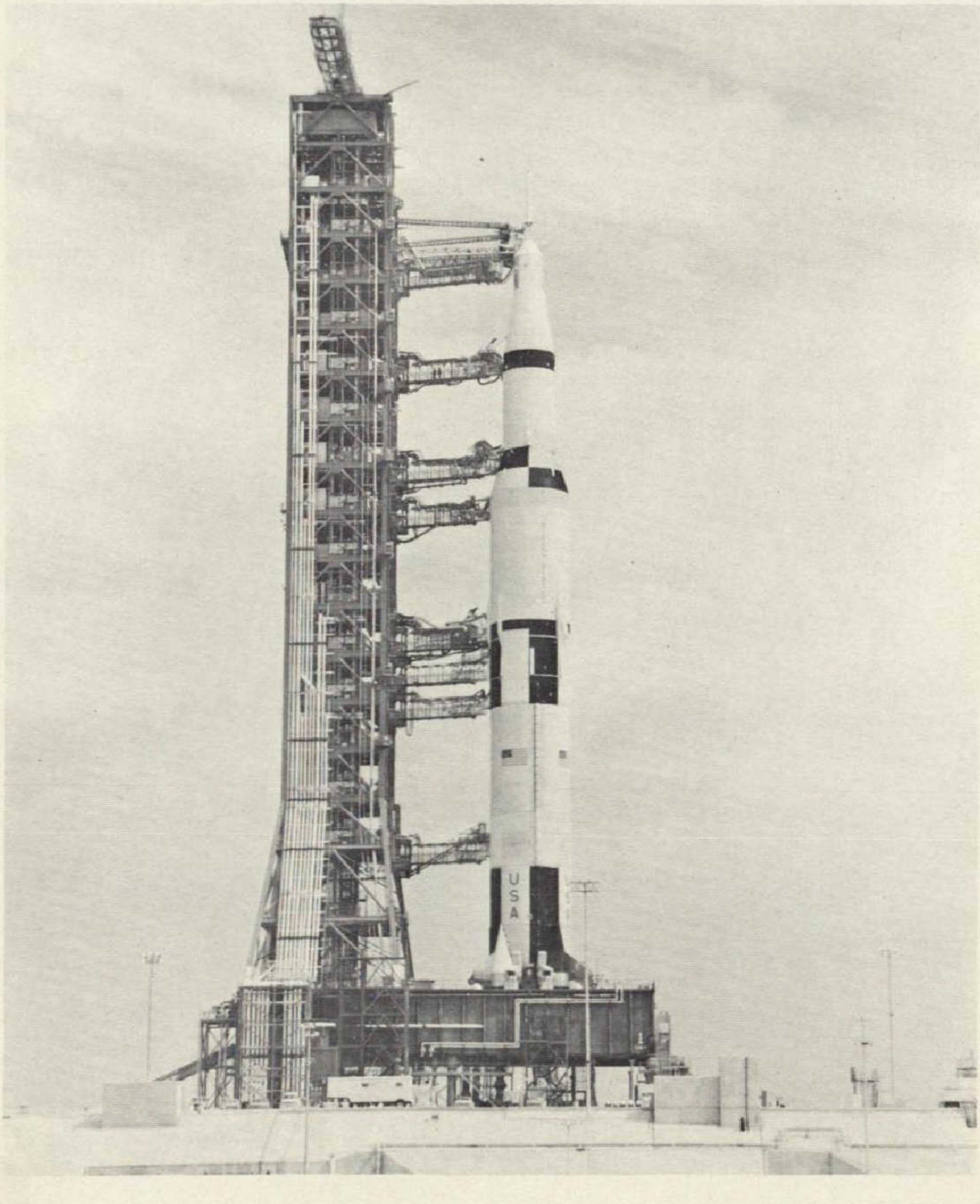
The 6,000,000-pound Crawler that transports the Apollo/Saturn V on its launcher and the Mobile Service Structure.



test taught the crews a great deal. They are confident that they can reduce the transit time to less than 12 hours without disturbing a single vital connection between rocket and umbilical lines.

Two identical and independent hydraulic servo systems are provided in each crawler for leveling. Level sensing and control are initiated by a

Apollo/Saturn V on its Mobile Launcher at Pad A, Launch Complex 39.



manometer, much like an enormous carpenter's spirit level, whose horizontal tube is 130 feet long. It contains two transducers which sense errors in leveling and transmit error signals to the servo system. In turn, this system operates two variable control pumps, one for each diagonal axis. The pumps force oil into hydraulic support cylinders at each corner of the platform to level the chassis and support the entire load of the mobile launcher.

Steering is accomplished mechanically. Two double-acting cylinders at each of four traction units turn the crawler at 10 degrees per minute. The minimum turning radius is 500 feet. Power is supplied by two 2,750-horsepower diesel engines driving four 1,000-kilowatt generators which feed 16 traction motors mounted on track drive. Two more 750-kilowatt generators are driven by two 1,065-horsepower diesels to power the systems for leveling, jacking and steering.

In operation, the crawler slips under the mobile launcher and its jacking system engages fittings under the platform. The launcher is raised off the support pedestals and carried into a high bay of the Vehicle Assembly Building. Then the booster stage of Saturn V, brought into the transfer aisle from the Barge Terminal on a low-bed transporter, is lifted into vertical position by the 250-ton crane, raised over an opening between the bay and transfer aisle, and gently lowered to the launcher base. After checkout of the second stage in a low bay cell, it is carried into the transfer aisle by crane, lifted and deposited atop the first stage. Next, the third stage is mated with the second, then the instrument unit is added. The assembled Apollo spacecraft, 54 feet tall, is delivered to the VAB from the Spaceport Industrial Area, hoisted by the powerful crane and placed atop the instrument unit. As the final act of the stacking operation, and only after all VAB tests are completed, the launch escape system is mounted atop the Apollo.

When the vehicle is ready for the firing site, the crawler returns to the high bay, jacks up the mobile launcher and transports it with the rocket aboard to the pad. The crawler burns 250 gallons of diesel fuel every hour of operation.

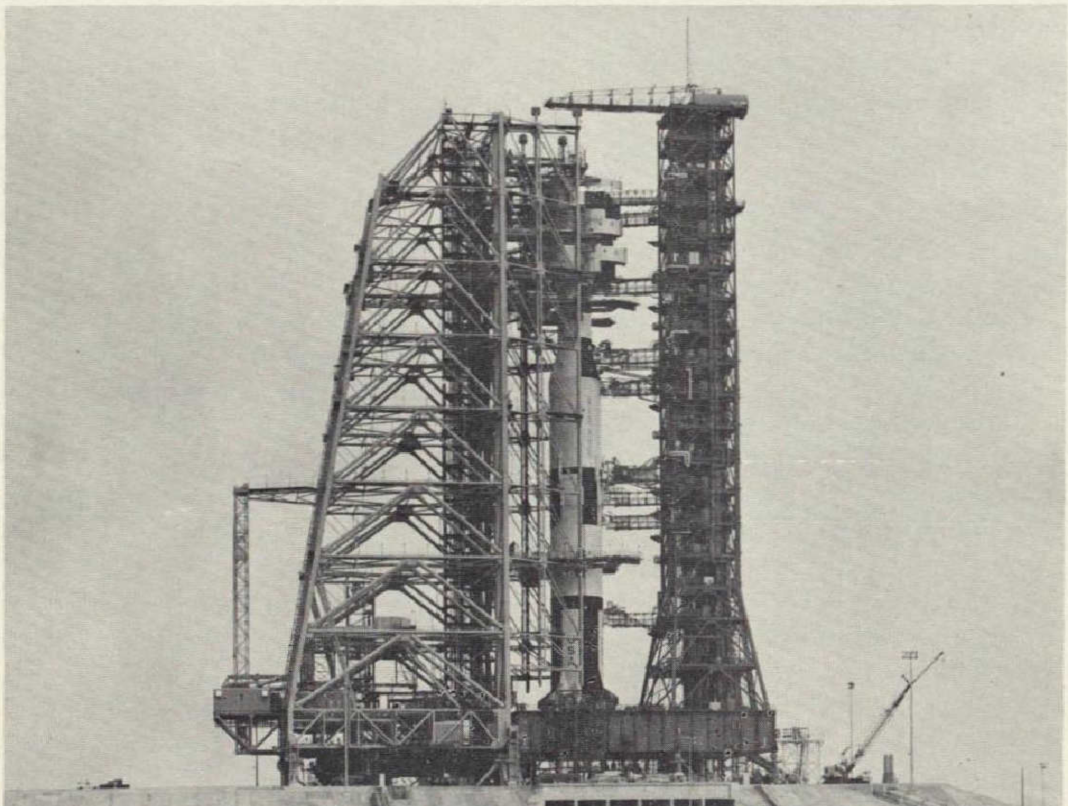
Since the combined masses of the crawler, mobile launcher and Saturn V weigh over 18,200,000 pounds, the roadway to support them is of far different type than the normal highway. It is called the Crawlerway and is 130 feet in width or just about the dimensions of the New Jersey Turnpike. Each lane is 40 feet wide and laid out on 90-foot center lines. To prepare its base, more than 3,000,000 cubic yards of fill were dredged from the adjacent barge channel and allowed to compact the subsoil to 95-per cent density, almost the hardness of rock. Six feet of crushed stone was then applied and packed to maximum

density. Above this layer is 12 inches of selected hydraulic fill. The bed was topped and sealed against moisture with an asphaltic prime coat and then covered by loose Alabama river rock, eight inches deep on curves and six inches deep on the straightaway. The loose rock surface eases friction on the crawler treads, particularly during the time when the machine negotiates curves.

Looking for all the world like a monstrous turtle, the machine straddles a grassed median as it crawls forward, two sets of trucks on either side of the median, the operator manipulating a control stick in a glass-enclosed cab mounted over the forward trucks on the right side.

Midway between the VAB and Pad A, an extension of the Crawlerway veers to the northeast and connects with the second launch site, Pad B. Near this junction is the parking site for another major element of the mobile concept which is utilized in launch preparations — the 9,400,000-pound Mobile Service Structure.

The Mobile Service Structure alongside Apollo/Saturn V provides 360-degree access to the space vehicle.



V

The Firing Site

HOUSE movers might envy NASA if they saw the skeletal structure of a 40-story building moving majestically along a highway on the back of the turtle-like Crawler dwarfed by its cargo. This is the Mobile Service Structure, a 402-foot steel trussed tower equipped with passenger freight elevators, power plant, air conditioning equipment, communications and television systems, and a computer.

The structure measures 135 by 132 feet at its base, or half the size of a football field, and is 113 feet square at the top. It has five enclosed work platforms, two of which are self-propelled, designed to embrace upper portions of the Apollo/Saturn V space vehicle at the launch site. Several platforms enable technicians to perform final inspections, to load hypergolic and cryogenic propellants in the spacecraft, to place ordnance items aboard, and conduct final preparations for the lunar module, command and service modules, and launch escape system.

The latter is a rocket-powered device which, in emergency, would lift the Apollo spacecraft with astronauts aboard away from the launch vehicle, carrying them to a safe height. Then parachutes would deploy and allow the spacecraft to drop back into the ocean where the crew could be rescued.

Originally, the mobile service structure was conceived as a fixed ordnance installation and arming tower. It was converted in mid-1962 to the mobile configuration. Designs were completed by Rust Engineering Co. in July 1964 and the structure was built by Morrison-Knudson-Perini-Hardeman starting in September of the same year. It was completed and undergoing tests with the Crawler by late 1966.

By positioning the structure next to the Saturn V on the pad it is possible to maintain the air conditioned environment required for final servicing of the Apollo as it rests atop the rocket 320 feet above its base. Weighing 9,400,000 pounds, the structure is carried to the pad by

the Crawler after mobile launcher and rocket are in position. Prior to launch, the Crawler returns the structure to its park position one mile from the firing site. During the remainder of the countdown, the Apollo/Saturn V and mobile launcher stand on the pad until liftoff occurs and the fully fueled vehicle, weighing more than 6,000,000 pounds, rises from the launcher.

There are two firing sites, or launch pads, resembling ancient Mayan pyramids. The first, or Pad A, was built by Blount Bros. and M. M. Sundt Corp. between November 1963 and October 1965 from designs of Giffels and Rossetti, Inc. The same contractors built the Crawlerway over its 18,000 feet length between the VAB and Pad A.

The critical item influencing design of the pad was the size and type of flame deflector which would be employed. This is a heavy steel device which directs sideward in an inverted V-pattern the downward exhaust of the five first stage engines. To avoid the effect of winds at higher levels on the space vehicle, it was desirable to keep the 364-foot Saturn V as close to the ground as possible. Consequently a two-way, wedge type flame deflector weighing 350 tons was adopted, allowing placement of the rocket almost immediately above the deflector which is 42 feet in height and 48 feet wide at the base.

Since the water table is close to the surface, it was decided to mount the flame deflector at ground level. A trench lined with fire resistant brick was designed which is 58 feet wide and 48 feet high. In turn, this fixed the height of the pad surface. Once the width and height of the pad had been determined, these parameters fixed the width between treads of the Crawler which had to straddle the flame trench while positioning the mobile launcher and rocket above the flame deflector.

The entire pad area was under water and more than 4,500,000 cubic yards of fill were dredged from the Banana River to prepare the site for construction. To achieve consolidation of the subgrade beneath the heavy launch pad, surcharge was pumped and moved to a height of 80 feet. The resulting multi-level, truncated pyramid stood out impressively on the flat terrain. During months following placement of the outsized sand pile, measurements showed that it settled about four feet and properly compressed the soil beneath. Then part of the surcharge was removed to bring the fill to permanent elevation.

The pad is roughly octagonal in shape and covers about one-half of a square mile. Its center is concrete hardsand. During operations, the mobile launcher supporting the Saturn V rocket is secured to six mount mechanisms located on the pad surface. Other fixed facilities on the pad include a hydrogen service tower, fuel system service tower, and electrical power pedestal.

Below the surface are several floors. A terminal connection room houses electronic equipment which is part of the communications system connecting the mobile launcher and the firing room in the Launch Control Center. Other enclosures house environmental control systems, high pressure gas storage systems, and the emergency egress room for astronauts or the personnel who must remain on the launch site until the last minutes of a terminal countdown. A metal chute extends upward from the room to the base of the mobile launcher. It could be used for quick access to the room which is lined with foam rubber to break the force of rapid descent. Since the room is buried deep within the reinforced concrete, earth revetted pyramid, it is blast proof.

An independent water system is employed at the pad to cool the flame deflector. A hydro pneumatic tank with capacity of 25,000 gallons provides a flow of 50,000 gallons per minute for 30 seconds. Another water system provides flame trench cooling and fogging to prevent damage from the rocket exhaust. A redundant pumping system forces the water through high pressure steel pipes and nozzles. At the proper instant, a three-second full opening of a 36-inch valve releases the deluge.

Located about the perimeter of the pad are pressure storage tanks for RP-1, the kerosene type fuel consumed in the Saturn V first stage; liquid oxygen at minus 297 degrees Fahrenheit employed in all three stages, and liquid hydrogen at minus 423 degrees Fahrenheit which fuels the second and third stages of the rocket. Holding ponds have been provided within the area for retention of spilled fuel and waste water. There is also a burn pond for disposal of hydrogen gas boil-off. Stainless steel, vacuum jacketed pipes carry the liquid oxygen and hydrogen from the storage tanks to the pad, thence to the mobile launcher and ultimately to the tanks inside the rocket.

The quantities of fuels and oxidizers required for a flight are prodigious. The first stage carries 340,900 gallons of liquid oxygen and 205,900 gallons of kerosene weighing 4,400,000 pounds. Second stage tanks hold 82,700 gallons of liquid oxygen and 263,000 gallons of liquid hydrogen or a combined weight of 930,000 pounds while the third stage contains 20,650 gallons of liquid oxygen and 72,860 gallons of liquid hydrogen, weighing 230,000 pounds.

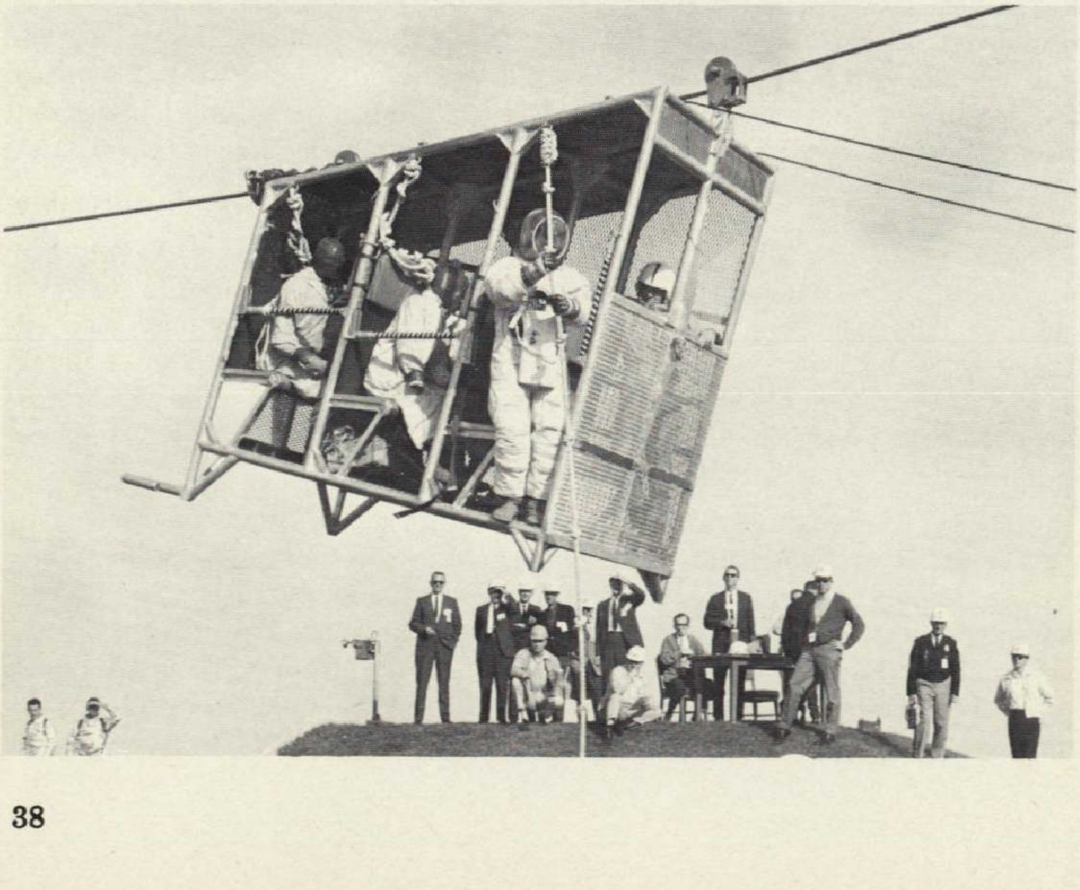
Fueling requires several days of carefully coordinated effort. The spacecraft is loaded first with hypergolic propellants. A tanker van carrying 96,000 pounds capacity of nitrogen tetroxide pulls up beside the Mobile Service Structure and fill lines are connected to it. The oxidizer is transferred at 60 gallons per minute to the Apollo service module which requires 2,500 gallons. Next, about 60 gallons are loaded into the lunar module ascent and descent tanks and reaction control system.

Next day a tanker of 43,000 pounds capacity transports aerozine-50 fuel to the site and its fill lines connect with a separate fuel distribution system of the service structure. About 2,100 gallons of the fuel are loaded into the Apollo service module and 1,200 gallons in the lunar module tanks. A small and separate source provides 100 gallons of monomethylhydrazine, and 25 gallons of nitrogen tetroxide are loaded into two auxiliary propulsion system tanks of the Saturn V third stage at the same time the spacecraft is fueled.

After the spacecraft fueling, the launch crews load the Saturn V. This operation is remotely controlled by computers directed from the Launch Control Center. The computer measures the amount of propellant within the rocket by means of probes inserted in each stage while the computer inside the mobile launcher controls flow rates by modulating loading valves within each stage inteface.

First the RP-1 fuel is taken aboard, pumped from three 86,000-gallon reservoirs located 1,350 feet from the pad at a rate of 2,000 gallons per minute. It requires about 100 minutes to transfer 206,000

Astronaut Stuart Roosa prepares to leave cab at end of test run down 2,000-foot wire from the 320-foot level of Mobile Launcher at Pad A, Complex 39. This system is one of the emergency escape modes available to Apollo crews.



gallons of fuel. Next, as the terminal count begins on the third day, the cryogenic propellants — liquid oxygen and liquid hydrogen — are pumped into the vehicle. The liquid oxygen supply is maintained in a 900,000-gallon capacity sphere 1,450 feet from the pad. Two 2,500-horsepower pumps flow the lox, as it is known, through a 14-inch diameter line at 10,000 gallons per minute. A smaller line and pumps are utilized for replenishment of liquid oxygen lost due to boil-off.

The liquid hydrogen container is 850,000-gallon capacity and situated 1,450 feet from the pad. About 335,000 gallons are drawn from this source for the second and third stages. The remainder is used to replenish and cool. The fuel is pressure fed from tank to rocket via a 10-inch diameter vacuum jacketed line at 10,000 gallons per minute. Pressurizing gas at 75 psig is obtained by tapping 250 gallons per minute of liquid hydrogen from the main storage tank and passing it through a heat exchanger. The liquid is converted into gas and routed back into the tank. When fueling has been completed, the Apollo/Saturn V is ready for launch.

Pad B and the 7,000-foot extension of the Crawlerway to it were built by George A. Fuller Co. starting in December 1964. It was completed and ready for use in late 1968, giving the Space Center a backup capability in the event that some unforeseen problem denied the use of Pad A for a considerable period, or making it possible to prepare two Saturn V vehicles for launch in rapid succession.

Other utility buildings are located within the launch complex. The master plan provides for siting another facility to prepare nuclear propulsion elements when these become available for upper stages and long duration manned space flights.

Stopping short only of actual launch, the entire complex and mobile concept showed up well during a stiff testing period in 1966. For this purpose, the Marshall Space Flight Center fabricated the AS-500F vehicle to check out launch facilities and train the rocket handling crews. It was precisely the shape and weight of the flight version and contained all the tankage, lines, electrical systems and other components by means of which to verify the launch facilities and equipment, except for engines.

Erection of the 500F vehicle began January 28, 1966, when a Crawler moved a mobile launcher into high bay 1 of the Vehicle Assembly Building. The first stage was erected on the launcher March 14. Ten days later the second stage was added and the third stage was erected March 29. Next day the instrument unit was placed atop the third stage. A dummy Apollo, lacking only a lunar excursion module, was assembled in the VAB's lofty transfer aisle May 2 and hoisted

atop the Saturn V. After three weeks of combined electrical tests, the vehicle was ready for movement to Pad A.

Outside the building, contractors and Government personnel gathered with astronauts and officials of the Marshall, Kennedy and Manned Spacecraft Centers to await the presence of the gigantic assemblies. Dr. Robert Seamans, then the Deputy NASA Administrator, spoke briefly and crisply remarked: "We are now going to see if the idea works."

At his signal, the Crawler began slowly to emerge from the bay. Its red tower loomed high overhead and next to it was the gleaming white rocket — the largest in the U.S. space inventory — being seen in its full height for the first time, just five years after President Kennedy announced the program.

Sequential tests were conducted on the launch pad, employing the Mobile Service Structure as well. NASA was pleased with the results.

Dr. George E. Mueller, then Associate Administrator for Manned Space Flight, addresses guests at the rollout of Apollo/Saturn 500F, May 25, 1966. Also in attendance were Rep. Olin E. Teague, Texas, Chairman of the House Sub-committee on Manned Space Flight; Dr. Robert C. Seamans, then Deputy Administrator, NASA; Dr. Debus; Dr. Robert R. Gilruth, Director, Manned Spacecraft Center; Albert F. Siepert, then Deputy Director, Center Management, KSC; Major General Samuel C. Phillips, then Apollo Program Director, Office of Manned Space Flight; and Dr. Wernher von Braun, then Director, Marshall Space Flight Center.

VI

The Industrial Area

FIVE miles south of the launch complex, and connected with it by a four-lane divided parkway, is the Spaceport industrial area where more than 50 buildings of almost as many types accommodate diverse, launch-related activities.

Stretching over several blocks in the eastern portion, near the Banana River, are structures designed for Apollo spacecraft checkout and launch preparations. The largest is the Manned Spacecraft Operations building in which Walter J. Kapryan, Director of Launch Operations; Dr. Hans F. Gruene, launch vehicle boss; and John J. Williams, Apollo spacecraft director maintain offices. The structure contains almost 600,000 square feet of office, laboratory, and spacecraft assembly areas — the latter part consisting of a high bay 224 feet long and 100 feet high, adjacent to a low bay 251 feet in length.

In the high bay are two identical steel altitude chambers 55 feet high and 33.5 feet in diameter, large enough to receive the completely assembled Apollo spacecraft. This has three main elements — the command module, in which three astronauts occupy flight couches; a service module, carrying propulsion systems and life support systems; and the lunar module, the spacecraft in which two astronauts will descend to the Moon's surface and return to rendezvous with the Apollo orbiting the Moon. All three modules must be mated electrically for the altitude chamber tests which simulate the environment 250,000 feet above Earth.

Apollo flight crews live in bachelor quarters in the building during pre-flight preparations which stretch over weeks. They become intimately familiar with the flight systems for their mission and also undergo final procedures training in command and lunar module simulators. The quarters consist of three 3-man apartments, a small gymnasium, lounge and kitchen. Close by is a small but fully equipped medical clinic

for the pre-flight and post-flight examinations which determine effects of extended space flight on the human body.

In addition to routine checks, the astronauts must undergo three physical examinations as the mission approaches. The most critical occurs three days before launch. The first formal physical check is scheduled 10 days prior to flight and the last on the morning of the launch. A tilt table is used in many of the measurements to ascertain the effects of disorientation. Only after the physicians certify they are completely fit do the astronauts put on their space suits and board the spacecraft.

Elsewhere in the same building are laboratories concerned with the investigation of malfunctions, with lunar module radar, communications and environmental control systems, Apollo guidance and navigation, stabilization and control, electrical power, and bio-medical and flight experiments. There are also laboratories for instrument checkout and calibration and a U.S. Weather Bureau station, because accurate and timely weather forecasting is essential in manned launches.

Automatic checkout equipment for spacecraft, known as ACE, takes up much of the third and fourth floors. Thirteen identical ACE stations, interconnected with the participating centers, have been installed in four locations by NASA:

—six at Kennedy Space Center

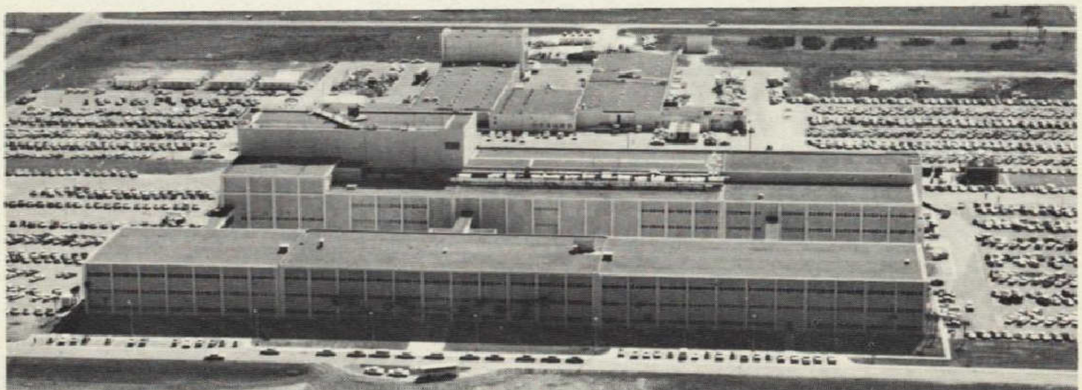
—two at Manned Spacecraft Center, Houston, Texas

—three at the North American Rockwell plant in Downey, Calif., where Apollo spacecraft are manufactured, and

—two at the Bethpage, N.Y. plant of Grumman Aircraft, maker of the lunar module.

ACE capabilities at the Center are in daily use since the Apollo program entered the operational phase to check out automatically the

Manned Spacecraft Operations Building



command, service, and lunar modules. These tests involve approximately 3,500 different measurements, many of which must occur so rapidly and in such numbers that it would be clearly infeasible to perform them manually. By contrast, the manual test techniques of the one-man Mercury spacecraft involved only 88 measurements.

The ACE system at the Space Center monitors spacecraft continuously via wide-band cables connecting Launch Complexes 34 and 37, at Cape Kennedy; Complex 39 on the Spaceport; four checkout cells in the Vehicle Assembly Building; two hypergolic and two cryogenic test facilities near the Manned Spacecraft Operations building; a static test stand for Apollo at Complex 16 on the Cape, and the two altitude chambers of the MSO building. ACE consoles are placed in the Launch Control Center firing rooms at Complex 39 in order that the test conductor may view any data he desires.

In the Fluid Test Area south and east of the Manned Spacecraft Operations building are specially equipped structures dispersed over a wide area because they are utilized for hazardous spacecraft tests and pyrotechnics installation. Both the Apollo and lunar modules undergo exhaustive checkouts here before their transfer to the Vehicle Assembly Building for mating with the Saturn V rockets or to Complexes 34 and 37 for mating with Saturn I launch vehicles.

A long, low cement building in which parachutes for Gemini missions were prepared was, in 1968, converted into a news center to accommodate the press who come to Florida to report NASA's launch operations. More than 1,000 technicians, photographers, commentators, and reporters attended the historic Apollo 8 lunar launch December 21, 1968.

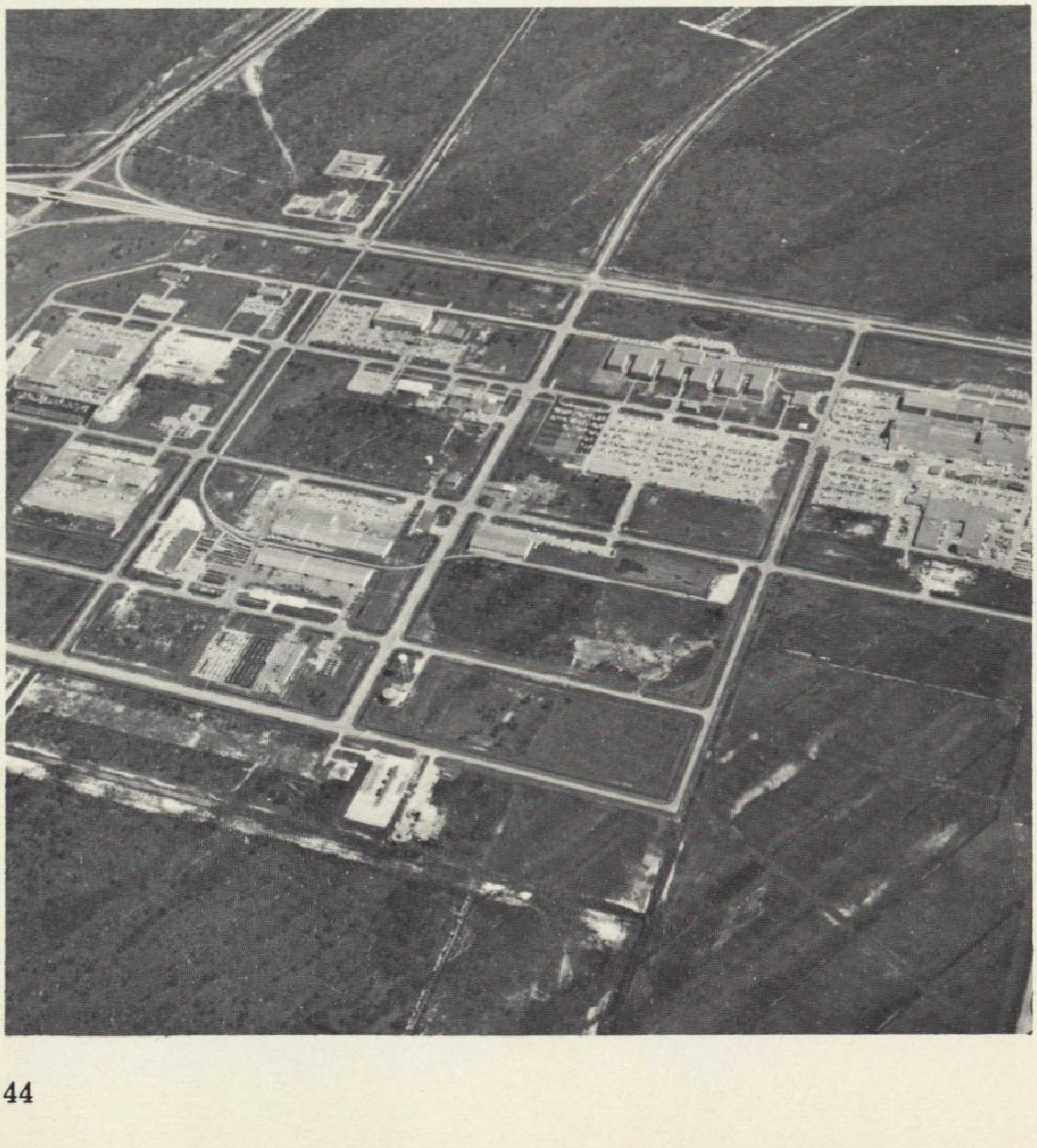
The Central Instrumentation Facility houses massive Univac, IBM, and General Electric computers and electronic equipment which receive and record data from the launch vehicles throughout the pre-launch preparations and the launch phase. Temperatures and humidity within this building are precisely controlled — 300 tons of air conditioning capacity cools the big computers. There are processing stations for telemetry, in-flight television, and prototype tracking and data; facilities for data reduction and data storage, presentation and distribution in real time to the Marshall Space Flight Center, primarily concerned with launch vehicle performance, and the Manned Spacecraft Center, primarily concerned with Apollo and lunar module spacecraft.

Atop the roof of CIF are dish antennae which receive telemetry signals and track Saturn rockets as they lift from the pads to follow pre-planned trajectories. Many kinds of measurements are received during flight such as temperatures within and outside the rocket, pro-

pellant flow rates, temperatures of engines, wind pressure, and other data valuable to engineers evaluating the vehicle's performance. Karl Sendler, Director of Information Systems, has his office in this building. He joined the Peenemuende rocket development team and came to this country with Dr. Debus and Dr. von Braun. He is an acknowledged pioneer in this specialized field.

Centrally located in the industrial area is Space Center headquarters where Dr. Debus, the Director, and his deputy, Miles Ross, have their offices. Here, too, are Raymond L. Clark, Director of Technical Support; George A. Van Staden, Director of Administration; G. Merritt Preston, Director of Center Planning and Future Programs; Grady F. Williams,

Aerial view of KSC Industrial Area



Director of Design Engineering; Brig. Gen. Thomas W. Morgan, Apollo-Skylab Programs Manager; Robert A. McDaris, Director of Quality Assurance; John R. Atkins, Safety Director; John J. Lacy, the Counsel; Dr. A. J. Knothe, Chief, Range Safety Staff; Walter P. Murphy, Jr., Director of the Executive Staff; William M. Lohse, the Procurement Director handling $300,000,000 annually in contracts; B. W. Hursey, Personnel Director; Frederic H. Miller, Director of Installation Support, and other key staff members.

In the main lobby stands a bust of the late President Kennedy who visited the Center a few days before his assassination. The bust is the work of Felix de Weldon who sculpted the Iwo Jima Memorial for the U.S. Marine Corps in Washington, D.C. It was commissioned by Mr. and Mrs. C. Thomas Clagett, Jr., and presented to NASA October 7, 1966.

Adjoining the headquarters is a NASA training facility. Since the techniques and disciplines of launch operations are relatively novel even to highly trained engineers and technicians recruited by the Government and its contractors, special classroom-type courses are provided for them here. Personnel working on spacecraft or launch vehicles must become thoroughly familiar with the hazards involved, particularly those associated with toxic fuels, and receive instruction in methods of protecting themselves and their fellow workers.

Apollo flight crews undergo highly sophisticated training in a separate facility which houses simulators that are exact duplicates of

KSC Headquarters Building

command and lunar modules. During training, the crews are in direct contact with flight controllers in the Mission Control Center at Houston, Texas, who monitor the astronauts' performance, confront them with sudden problems, and thus help condition them for unexpected contingencies that might occur during flight. Similar training devices are also operated at the Manned Spacecraft Center. The difference is that simulators at Kennedy are configured for the imminent mission while those in Houston prepare the crews for subsequent missions.

During three months of intensive training at Kennedy, the Apollo crew rehearses every moment of the assigned mission from liftoff to Earth return. Occupying a flight couch in the command module, an astronaut looking through one porthole observes Earth's surface beneath, and cloud formations as they look from an orbiting spacecraft, while another crewman can see the stars in their correct relative positions in the heavens as the spacecraft simulates orbit.

When they rehearse docking the Apollo with the lunar module, the astronauts see the latter come into view through their windows and can visually maneuver their spacecraft toward it. Later, as they rehearse lunar operations, two astronauts occupy the lunar module simulator. Looking out of its windows, they observe the Moon's surface just as it appears when they approach landing.

Rehearsing the descent maneuver, they can "fly" to within four feet of touchdown. Adding to the realism of this training is the photographic information concerning the Moon's surface obtained from such reconnaissance spacecraft as Ranger, Lunar Orbiter and Surveyor that photographed the surface in detail. The film provided by the Apollo 8 mission, however, brought a new dimension of reality to the training.

As the astronauts practice liftoff from the Moon in the lunar module, they can observe the orbiting Apollo spacecraft and maneuver towards it for the docking that will enable them to reenter Apollo for Earth return. Closed circuit television cameras mounted within the spacecraft permit the controllers in Houston as well as their assistants at Kennedy to monitor the astronauts' performance.

Precautions are taken to assure the astronauts privacy in their living quarters. Their daily movements through the Manned Spacecraft Operations building, however; in the flight simulators, at launch complexes, in mission review conferences, and other engagements make them familiar to the launch team. They respond cheerily to the greetings of secretaries, guards, technicians, and engineers.

An incident concerning John Glenn's flight illustrates the camaraderie between ground crew and astronauts. His friends at the Center worried that John might become tense in the moments before he lifted

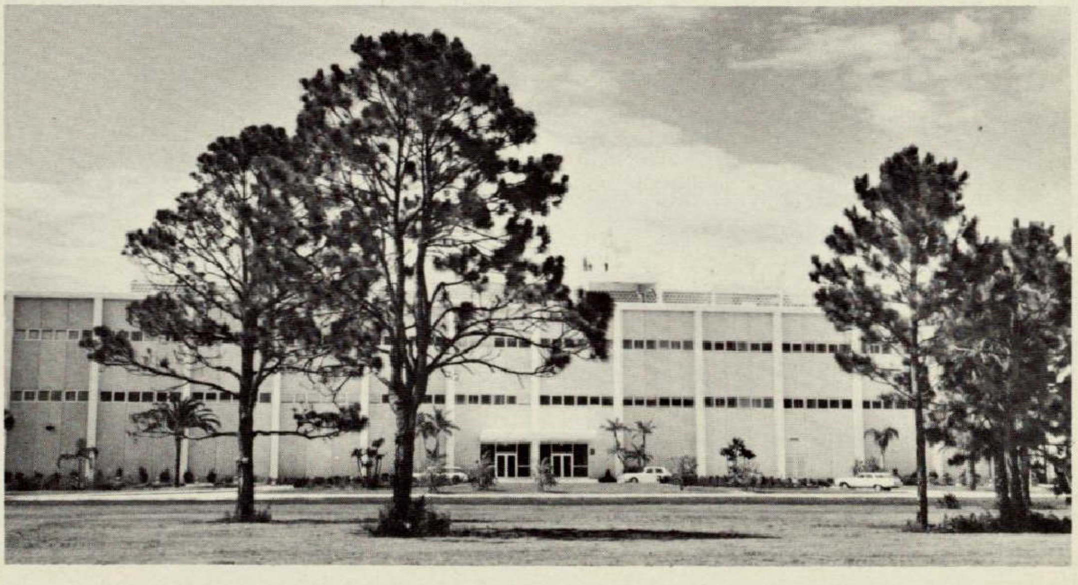
off in the Mercury Atlas. So they prepared a surprise. As the pilot went through last-minute tasks, he was required to look into a periscope. There he saw the image of a beautiful pinup girl and under her trim figure these words: "It's just you and me in space, John baby!" Glenn laughed and the crew was delighted. But the flight had to be postponed. Next time he looked into the periscope, John saw an old, bedraggled scrub lady and the words: "What did you expect after yesterday's fiasco?"

When not assigned to a launch as crew, astronauts send their wives and children to the Space Center to observe flights and sometimes accompany them if their duties permit. Rarely does the wife of a crew member elect to witness her husband's departure from Earth at the launch site. Usually, she remains home with her children and watches events at the launch center by television.

Gemini and Apollo crews followed a tradition of inviting close friends or dignitaries — sometimes the clergy — to join them for breakfast or lunch in their quarters on launch days. Congressman Olin D. Teague of Texas, chairman of the Subcommittee on Manned Space Flight and an ardent supporter of the space program; Dr. Robert Gilruth, Director of the Manned Spacecraft Center; Dr. George Mueller, NASA Associate Administrator for Manned Space Flight; Dr. Debus and other NASA officials have been among the guests. Vice President Spiro T. Agnew and NASA Administrator Dr. Thomas O. Paine were guests of the Apollo 10 crew on the eve of launch, and Dr. Paine returned in April 1970 for dinner with the Apollo 13 astronauts.

Elsewhere in the industrial area are spacious warehouses in which supplies to provision a city of 23,000 are stored — including com-

Central Instrumentation Facility



ponents for launch equipment, rockets and spacecraft. An Industrial health building houses a small hospital, with physicians and nurses charged with taking care of accidental injuries and safeguarding the health of launch personnel. The General Services Administration operates a garage and service station where sedans, buses, trucks and other vehicles utilized by the Center and its contractors are maintained. GSA has assigned 1,257 vehicles to the Center, 499 of them passenger type and 758 haul cargo. The fleet averages 1,300,000 miles per month.

A main cafeteria operated by Automatic Retailers of America, Inc., employed by the KSC Employees' Exchange Council, feeds hundreds daily and supplies other cafeterias conveniently located with the main concentrations of personnel. These are supplemented by mobile lunchrooms which transport food directly to remote locations. Several snack bars including one in the Vehicle Assembly Building are maintained by the Florida Council for the Blind which receives the income. There are a sewage treatment plant, power stations, and a telephone exchange large enough to serve the nearby city of Cocoa, Florida. Approximately 10,000 telephones are required in daily service.

To obtain adequate supply of potable water, NASA contracted with the City of Cocoa and contributed $1,000,000 to defray the cost of an additional well in the city's water field located in adjacent Orange County and the cost of installing a connecting main between the Center and Merritt Island 10 miles south.

While the headquarters of Canaveral District, Corps of Engineers is outside the Center, military and civilian personnel working directly in the NASA construction program occupy buildings at Complex 39 and in the industrial area. Col. George A. Finley was the District Engineer when the major projects began in 1963. He was succeeded by Col. William L. Starnes. Col. G. H. Newman took over the District in January 1969. Col. Joseph A. Bacci was resident engineer at Complex 39 from June 1963 until May 1966 when the was succeeded by Ralph L. Horne. Other key figures in the construction supervision effort were Col. J. Newton Cox, Col. Remi O. Renier, Col. Robert L. Bangert, Lt. Col. William W. Hall, Jr., Donald E. Eppert and Joseph L. Harvey.

Incredible quantities of materials and a large-scale transportation program were required to build the Spaceport. In four years, 4,379,692 tons of cement, sand, gravel and aggregates were delivered to the Center, plus 569,026 tons of steel and lumber, 22,000 tons of wire, cables, conduit and pipe, and 8,250 tons of components for the mobile launchers, crawlers, and cranes installed in the Vehicle Assembly Building, and other structures. Of these quantities, 3,840,000 tons arrived by truck, 1,127,750 tons by rail and 11,218 tons by barge.

VII

The Center Grows — and Reduces

EVOLUTION of the Kennedy Space Center from a small, do-it-yourself Government laboratory team to the complex management organization of today is an example of the forcing function of the national space program during the Apollo program which began in 1961 and culminated in 1969.

When NASA came into being October 1, 1958, the Center's Director, Dr. Kurt H. Debus, then supervised 281 Federal personnel in the Missile Firing Laboratory. In turn, this laboratory was part of the Development Operations Division, Army Ballistic Missile Agency at Redstone Arsenal, Alabama. Dr. Wernher von Braun was the division chief and Major General J. B. Medaris commanded the agency. It was responsible for developing two weapons systems, the Redstone 200-mile range ballistic missile, and Jupiter, a 1750-mile missile later turned over to the Air Force for deployment in Italy and Turkey. Later the agency developed the Pershing solid propellant missile which replaced Redstone in the Army's weapons systems, and executed the early phases of the Saturn launch vehicle development subsequently transferred to NASA.

In the Army program, Chrysler Corporation fabricated both Redstones and Jupiters in a defense plant located near Detroit, Michigan. Development type missiles were shipped to Cape Kennedy where the launch team checked them out in hangars and prepared them for flight. Then they were transported to Launch Complexes 26 and 56, which had been constructed by the Army for this purpose. Following erection on the launch pads, they were checked a final time, fueled and launched. Beginning with the first Redstone in 1953 and the first Jupiter in 1957, the team successfully fired many of these rockets and modified versions of both, called Jupiter C and Juno. At a later point in time, the team fired the Pershing missiles and NASA's manned Mercury Redstones.

The team compiled an impressive record of historic flights, such as:

Sept. 19, 1956 — first Jupiter C carried a payload of 84 pounds 3,000 miles down range.

Aug. 7, 1957 — first recovery of a reentry body, an ablation protected nose cone, carried over 1,500-mile range by a Jupiter C.

Jan. 31, 1958 — launched Explorer I, the first U.S. earth satellite, on Jupiter C. The satellite weighed 30.8 pounds.

Mar. 3, 1959 — Pioneer IV, a 13.4 pound satellite, launched by Juno II, transmitted signals to Earth over a range of 416,000 miles after it passed the Moon and became a satellite of the Sun.

May 28, 1959 — launched two monkeys, Able and Baker, in a Jupiter rocket. The animals reached an altitude of 300 miles and were recovered alive 1,700 miles down range. The larger, rhesus monkey, which died later, is on display in the Smithsonian in Washington as the first U.S. space traveler.

Feb. 25, 1960 — first launch of Pershing.

Jan. 31, 1961 — NASA's Mercury Redstone carried a chimpanzee named Ham who survived the suborbital flight.

May 5, 1961 — Alan B. Shepard, Jr. became the first U.S. astronaut, traveling on Mercury Redstone to an altitude of 115 miles at a velocity of 5,100 miles per hour.

Jul. 21, 1961 — Virgil Grissom became the second U.S. space pilot aboard another Mercury Redstone.

In 1959, President Eisenhower decided to consolidate the space pro-

LAUNCH RECORD OF APOLLO/SATURN TEAM

	Redstone	Jupiter C	Jupiter	Juno II	Mercury-Redstone	Saturn I	Saturn V
1953	1						
1954	4						
1955	6						
1956	9	1					
1957	10	2	7				
1958	10	6	5	1			
1959	2		16	3			
1960	3		3	2	2		
1961	3		3		4	1	
1962			1			2	
1963						1	
1964						3	
1965						3	
1966						3	
1967							1
1968						2	2
1969							4
1970							1
	48[a]	9[b]	35[c]	9[d]	6[e]	15[f]	8[g]*

[a]42 successes, [b]5 successes, [c]28 successes, [d]5 successes, [e]5 successes,

[f]15 successes, [g]8 successes.

*Through June 1970.

The team also launched 5 successful Ranger flights in 1961 and 1962, 13 successful Pershing rockets in 1960 and 1961, a Centaur vehicle in 1962 and two Mariner flights in 1962.

gram and transferred the Army's launch team, together with the main body of Dr. von Braun's rocket development organization, to NASA effective July 1, 1960. The transfer involved 5,000 civil servants and extensive facilities on Redstone Arsenal and at Cape Kennedy. The launch team became the Launch Operations Directorate of NASA's center in Huntsville in 1960. Another major change occurred in 1962 when NASA separated the launch organization from the Marshall Space Flight Center and created a Launch Operations Center at Cape Kennedy.

Dr. Debus and his relatively small staff faced a number of challenging tasks at the time:

—proceeding with construction of Complex 37, second of the large Saturn I facilities on Cape Kennedy

—continuing launches of the Saturn I vehicles which began at Complex 34 in 1961

—supervising construction of the NASA Spaceport on adjacent Merritt Island

—continuing the buildup of Civil Service manpower to operate a full-scale NASA field installation required to perform such basic functions as procurement, security, personnel administration, resources management, design and procurement of unique ground equipment for launch vehicles and spacecraft of the Apollo program

—working out mutually satisfactory arrangements with the Marshall Space Flight Center and Manned Spacecraft Center for the checkout and test operations to be performed at Kennedy on their launch vehicles and spacecraft.

Lack of office space on Cape Kennedy complicated the situation in the Spring of 1963 when the Center's major growth began. Existing hangars and office structures were fully utilized for military activities and by some NASA and contractor elements working both for the military and space agency. NASA leased office space in Cocoa Beach, 12 miles to the south, to house procurement, personnel administration, security, financial management and other units. Several hundred Space Center employees remained in Huntsville where they required daily contact with the Saturn designers of Marshall Space Flight Center in order to design and procure matching ground equipment for the heavy launch vehicles. They rejoined the main body of KSC in 1965 when the items they designed began arriving at the Spaceport.

The rapidly expanding staff occupied prefabricated wooden structures and trailers squeezed into parking lots on the Cape. Not until 1965 did it become possible to collect KSC personnel in one installation. They moved into the new laboratories, assembly buildings and offices as the new Merritt Island facilities became available. Some organizations continue to occupy offices, hangars, laboratories and launch complexes on

the Cape in close proximity to the pads from which they fire unmanned spacecraft aboard Delta and Centaur vehicles.

Thousands of contractor personnel supporting NASA programs share work space on the Cape or the Spaceport with Government employees, who comprise a minority of the total manpower. Center Headquarters was enlarged as the force built up to a peak of 26,500 in September, 1968. Contractors established local offices in adjacent communities including Titusville, Merritt Island, Cocoa Beach and Cape Canaveral.

The series of Saturn I launches continued as NASA's construction program shifted into high gear. The fifth Saturn launched in January 1964 carried into earth orbit a mass 1,000 times heavier than the first 30-pound U.S. satellite. For this operation, a second stage fueled with liquid hydrogen was flown for the first time. Between 1961 and 1965, the launch group assigned to Saturn successfully fired 10 vehicles under direction of Dr. Debus. The last three placed into orbit huge, bat-wing satellites weighing 3,200 pounds, called Pegasus. They measured the frequency, size and velocity of micro-meteoroid particles striking the wings in space. Pegasus swept through the areas in near-Earth space in which manned Gemini and Apollo spacecraft operated. The satellite was developed by the Marshall Center for NASA's Office of Advanced Research and Technology.

NASA honored the KSC team with a Group Achievement Award October 9, 1964, for "exceptional achievement in the preparation, checkout, and successful launches of Saturn I, the first generation of the Nation's most powerful launch vehicles." KSC then employed 1,740 Government personnel.

The Center's mission and capabilities were expanded in 1964 and 1965 by significant actions directed by NASA Administrator James Webb, who decided there should be an integrated NASA organization to launch medium and heavy class vehicles, whether manned or unmanned.

The Manned Spacecraft Center in Houston, Texas maintained a Florida Operations Group at Cape Kennedy which consisted of 450 civil servants and supporting contractors, including McDonnell Aircraft Corporation which fabricated Mercury and Gemini manned spacecraft. Having completed the Mercury program in 1963, the MSC Group was then preparing for the Gemini series that commenced with two unmanned test missions in 1964 and 1965 followed by 10 successful manned flights in 1965 and 1966. Gemini carried the nation into the forefront in manned space operations, logging hundreds of hours in orbit and performing rendezvous and docking maneuvers with Agena target vehicles, launched also from the Cape on Atlas rockets. G. Merritt Preston, a Government career manager with a broad background in aeronautics, led the MSC Group. For his management of Mercury launch operations, he received the NASA Outstanding Leadership award.

Several members of his team won special recognition for outstand-

ing performance during the Gemini program. Superior achievement awards were presented to Arthur M. Busch, Chief, Flight Systems Division; John Janokaitis, Jr., Deputy Manager, Gemini Operations; Joseph M. Bobik, Chief, Quality Surveillance Division; Wiley Williams, Manager, Gemini Operations and George F. Page, Chief Test Conductor. Mr. Preston accepted the Group Achievement Award for the spacecraft launch team while President Johnson, in a Houston ceremony, presented NASA's Medal for Outstanding Leadership to John J. Williams, Director of Gemini Spacecraft Operations.

Other key members of the team included E. N. Sizemore, planning and technical support office; G. T. Sasseen, ground systems division; W. R. Durrett, assistant to the Director; M. A. Wedding, assistant chief, flight systems; W. T. Risler, assistant chief for experiments; W. R. Meyer, project engineer, ground systems; C. D. Gay, spacecraft operations management and J. H. Dickinson, deputy chief, quality surveillance. Paul Donnelly, one of the senior managers of the Gemini team was named Associate Director for Operations, Launch Operations, in June 1970.

Early in 1965, prior to Gemini's first manned mission with Virgil Grissom and John Young, the Florida Operations Group was transferred to the Kennedy Space Center. Mr. Preston became KSC's launch operations director in which capacity he continued to direct Gemini operations for NASA. This involved working closely with the U.S. Air Force 6555th Test Wing which was responsible to prepare Titan II launch vehicles fabricated by the Martin Company. The former MSC team became a new Spacecraft Operations Directorate.

Its prime task is to prepare Apollo spacecraft — command, service and lunar modules — for flight. This entails close relationships with the astronauts assigned to each mission and with the Manned Spacecraft Center which designed and procured the spacecraft.

While Gemini launches occurred at Launch Complex 19 at intervals of two months in 1966, three Saturn IB vehicles were flown by the combined launch vehicle and spacecraft organizations. Two of them carried Apollo spacecraft in unmanned tests of the configuration and reentry heating protection. This version of Saturn develops 1,600,000 pounds thrust and weighs over 1,200,000 pounds at liftoff. Its most important mission was the launch October 11, 1968 of Apollo 7, first manned flight of the vehicle and spacecraft.

As the eminently successful Gemini program was concluded, Mr. Preston and the spacecraft group were honored for their achievements. Administrator James Webb conducted a ceremony at the Manned Spacecraft Center and praised their work. Subsequently, Mr. Preston became KSC Director of Design Engineering, moving from that post in 1970 to head up the new Directorate for Center Planning and Future Programs.

In late 1965, another exceptionally competent launch team joined KSC. Some of its members had been active in space projects since Project

2 ⊕

SPACECRAFT LAUNCHES

The NASA spacecraft team has participated in all U.S. manned flights from the first Mercury through Apollo.

MERCURY

May 5, 1961	Alan B. Shepard, Jr.	Freedom 7	15 minutes
July 21, 1961	Virgil I. Grissom	Liberty Bell 7	15 minutes
Feb. 20, 1962	John H. Glenn, Jr.	Friendship 7	4 hr., 55 minutes
May 24, 1962	M. Scott Carpenter	Aurora 7	4 hr., 56 minutes
Oct. 3, 1962	Walter M. Schirra	Sigma 7	9 hr., 13 minutes
May 15, 1963	L. Gordon Cooper	Faith 7	34 hr., 20 minutes

GEMINI

March 23, 1965	Virgil Grissom John W. Young	Gemini III	4 hr., 53 minutes
June 3, 1965	James A. McDivitt Edward H. White	Gemini IV	97 hr., 57 minutes
Aug. 29, 1965	L. Gordon Cooper Charles P. Conrad	Gemini V	190 hr., 56 minutes
Dec. 4, 1965	Frank Borman James A. Lovell	Gemini VII	330 hr., 35 minutes
Dec. 15, 1965	Walter M. Schirra Thomas P. Stafford	Gemini VI-A	25 hr., 48 minutes
March 16, 1966	Neil A. Armstrong David R. Scott	Gemini VIII	10 hr., 42 minutes
June 3, 1966	Thomas P. Stafford Eugene A. Cernan	Gemini IX-A	72 hr., 21 minutes
July 18, 1966	John W. Young Michael Collins	Gemini X	70 hr., 46 minutes
Sept. 12, 1966	Charles P. Conrad Richard F. Gordon	Gemini XI	71 hr., 17 minutes
Nov. 11, 1966	James A. Lovell Edwin E. Aldrin	Gemini XII	94 hr., 34 minutes

APOLLO

Oct. 11, 1968	Walter M. Schirra Walter Cunningham Donn Eisele	Apollo 7	260 hr., 9 minutes
Dec. 21, 1968	Frank Borman James Lovell William Anders	Apollo 8	146 hr., 51 minutes
March 3, 1969	James A. McDivitt David R. Scott Russell L. Schweickart	Apollo 9	241 hr., 1 minute
May 18, 1969	Thomas R. Stafford John W. Young Eugene A. Cernan	Apollo 10	192 hr., 3 minutes
July 16, 1969	Neil A. Armstrong Michael Collins Edwin E. Aldrin, Jr.	Apollo 11	195 hr., 19 minutes
Nov. 14, 1969	Charles P. Conrad Richard F. Gordon Alan L. Bean	Apollo 12	244 hr., 36 minutes
April 11, 1970	James A. Lovell John L. Swigert Fred W. Haise	Apollo 13	142 hr., 55 minutes

Vanguard when the Naval Research Laboratory stationed 26 civil servants at the Cape in 1956 to supervise Vanguard satellite launches. They successfully launched a Vanguard March 17, 1958 that became the second U.S. earth satellite.

NASA absorbed the Vanguard organization in 1958 and made it part of the Goddard Space Flight Center at Greenbelt, Maryland. The team launched NASA's unmanned scientific spacecraft during the next six years with a high degree of success, utilizing Delta, Atlas Agena, Atlas Centaur and Thor Agena vehicles. They launched 22 Deltas without a failure from 1965 through 1967.

Dr. Robert H. Gray managed the team made up of 125 Government personnel and 1,200 supporting contractors. He became the KSC director of unmanned launch operations when his group joined the Center. Mr. Gray was named deputy to the Director of Launch Operations in May 1970. His assistant, John J. Neilon, succeeded him as director of unmanned launches. A small complement is permanently assigned to the Western Test Range at Lompoc, California and launches some unmanned flights from that installation. The location is more favorable than Cape Kennedy for polar orbits; that is, flights involving transit of the satellite over North and South Poles while the Earth rotates beneath, making it possible for one spacecraft, for example, to scan cloud formations over any point on the globe.

As the Center's technical capabilities increased, a complex of supporting contractors joined the organization to furnish common services or specialized technical services. Expansion continued into FY 1969, as the statistics indicate:

EMPLOYMENT

	FY64	FY65	FY66	FY67	FY68	FY69	FY70
Civil Service	1977	2469	2654	2785	2911	3000	2967
Apollo Stage and Spacecraft Contractors	911	1748	5850	8032	6990	9160	4768
Unmanned Stage Contractors	188	1448	1331	1549	1553	940	632
Support Contractors	3204	4116	7739	9116	9829	9000	7011
TOTALS	6280	9781	17574	21482	21283	22100	15378

Including construction workers who move in and out, Corps of Engineers personnel, General Services Administration, and Eastern Test Range groups supporting NASA launches, the total NASA related employment at the launch center exceeded 26,000 in September 1968.

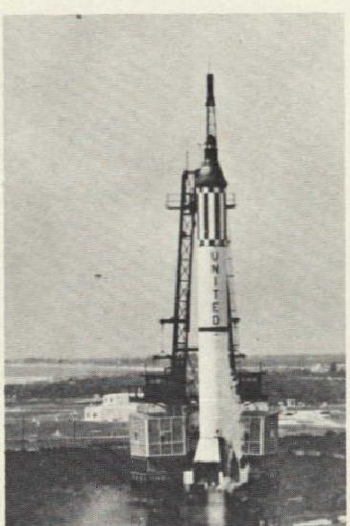
By this time, however, on the eve of the first three-man Apollo mission, Kennedy began to reduce its manpower. Major facilities construction projects were either completed, or nearing completion, hence there was no longer need for a design engineering capability at the same level. Between September and December 1968, more than 1,000 personnel

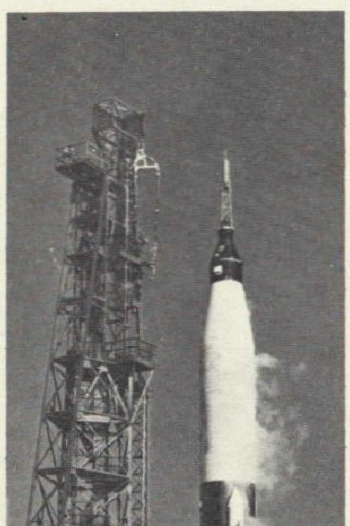
were separated from contractor payrolls. Included in this group were employees engaged in the Saturn IB launches at Complexes 34 and 37. It had been decided not to launch more Apollos with this vehicle since the Saturn V was ready to carry men to the Moon.

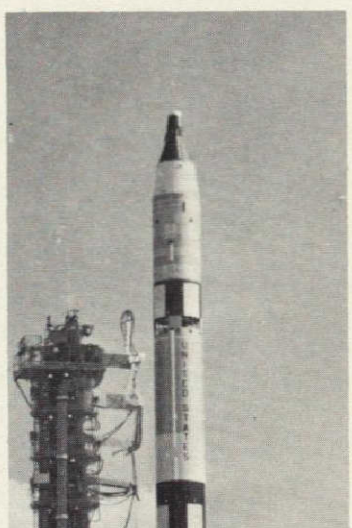
Again, in April 1969, the Center notified the community of a further reduction. There had been a national decision to slow down the pace of Apollo flights to the Moon after the first successful manned landing. Instead of launching Saturn V's at the rate of five per year, KSC expected to fire two or three annually. In the wake of Apollo 11, in July, action was taken to implement a major phase-down. Initially, 5,600 contractors and 155 Civil Servants were to be laid off over a period extending to June 1970. The objective was to retain the expertise of the launch organization within a total force of about 18,000 people.

By the Spring of 1970, KSC was well along the road to attaining that goal. Meanwhile, there was no longer prospect of three Apollos per year and the two-per-year rate seemed to be firm. As a result, the work force is expected to reduce to about 17,000 by June 30, 1970 and to remain at approximately that level for the next several years.

Lower left: Mercury Redstone, launched May 5, 1961, carried astronaut Alan B. Shepard on nation's first manned space flight. The suborbital flight lasted fifteen minutes. Lower center: Mercury Atlas prior to launch from Complex 14. Lower right: Gemini Titan lifts off from Complex 19.







VIII

Center Organization

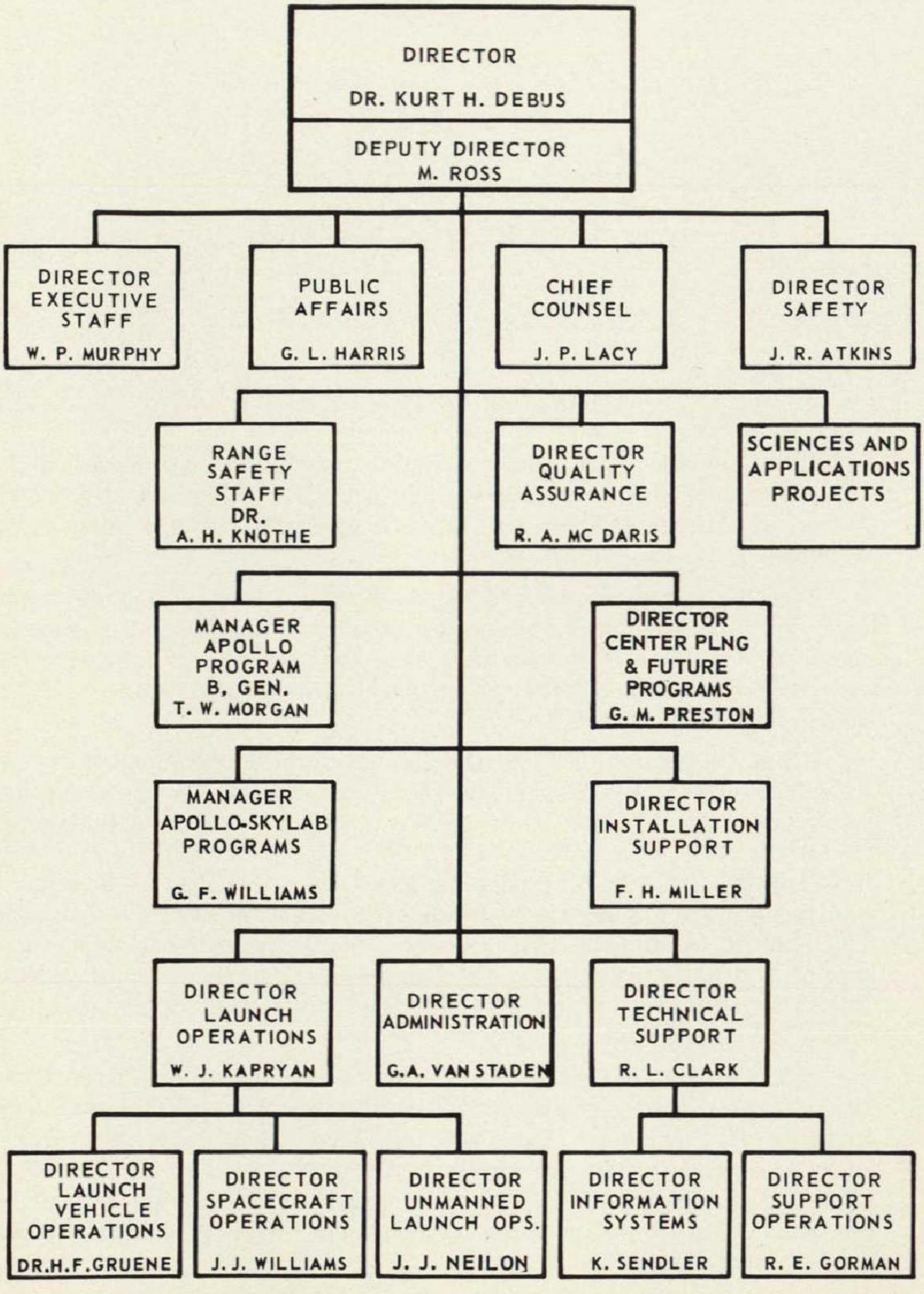
THE Kennedy Space Center's basic organization has remained virtually unchanged since June, 1966 when NASA approved a restructuring which streamlined and strengthened the Center's management resources.

Top leadership is provided by the Center Director and his Deputy along with a senior group consisting of a planning director, a program manager, four line operating directors, the director of administration and five staff officials. They meet weekly to formulate policy and consider operational matters.

From 1963 through 1969, the Deputy for Center Management was Albert F. Siepert. Mr. Siepert served as executive officer of the National Institutes of Health, the Government's largest medical research facility, for 10 years. He was summoned to NASA in October 1958 to become its first Director of Administration. A graduate of Bradley University, he won recognition for management leadership in a variety of research and development assignments. He left the Federal government this year to become a project manager in the Center for Research on Utilization of Scientific Knowledge which is part of the University of Michigan's Institute of Social Research.

Miles Ross, who became Deputy for Center Operations in September 1967, functions as the sole Deputy Director. A graduate of Massachusetts Institute of Technology, Mr. Ross has been active in rocketry for 20 years, participating in development of the Navy's Terrier missile and later in the Air Force Thor and Minuteman programs. He relinquished the position of Manager, Florida Operations, TRW Systems, to accept the Kennedy Space Center position.

An explanation of the respective contributions of the NASA Civil Service staff and personnel of the aerospace contractors is essential to


DIRECTOR
DR. KURT H. DEBUS
DEPUTY DIRECTOR
M. ROSS
DIRECTOR EXECUTIVE STAFF
W. P. MURPHY
PUBLIC AFFAIRS
G. L. HARRIS
CHIEF COUNSEL
J. P. LACY
DIRECTOR SAFETY
J. R. ATKINS
RANGE SAFETY STAFF
DR. A. H. KNOTHE
DIRECTOR QUALITY ASSURANCE
R. A. MC DARIS
SCIENCES AND APPLICATIONS PROJECTS
MANAGER APOLLO PROGRAM
B, GEN. T. W. MORGAN
DIRECTOR CENTER PLNG & FUTURE PROGRAMS
G. M. PRESTON
MANAGER APOLLO-SKYLAB PROGRAMS
G. F. WILLIAMS
DIRECTOR INSTALLATION SUPPORT
F. H. MILLER
DIRECTOR LAUNCH OPERATIONS
W. J. KAPRYAN
DIRECTOR ADMINISTRATION
G.A. VAN STADEN
DIRECTOR TECHNICAL SUPPORT
R. L. CLARK
DIRECTOR LAUNCH VEHICLE OPERATIONS
DR.H.F.GRUENE
DIRECTOR SPACECRAFT OPERATIONS
J. J. WILLIAMS
DIRECTOR UNMANNED LAUNCH OPS.
J. J. NEILON
DIRECTOR INFORMATION SYSTEMS
K. SENDLER
DIRECTOR SUPPORT OPERATIONS
R. E. GORMAN

understanding the teamwork of the Center. The Government selected industrial firms through a competitive negotiation process to develop and fabricate the rockets and spacecraft and provide specialized services either directly involved in launch operations or in supporting this principal mission of the Center. Government managers provide direction to the stage, or support service contractors who execute missions defined in the contractual documents. Certain designated Civil Service personnel working in directorates instruct the contractors, or monitor their performance. Other Government employees perform tasks which the Government needs to retain within its hands for statutory or policy reasons.

The Space Center exists only to perform launch missions assigned by NASA. The Office of Manned Space Flight in the agency's headquarters in Washington determines assignments in the Apollo and Apollo Applications programs while the Office of Space Sciences and Applications of the headquarters assigns launch missions for unmanned scientific satellites and space probes. Some launches are conducted also for the Office of Advanced Research and Technology, usually relating to the flight testing of new materials or systems which later find use in the manned and unmanned space exploration programs.

The Directorate of Launch Operations executes all launch assignments. It is the largest element of the Center and the focus of its mission. This Directorate controls and integrates the work of stage contractors at the launch site to the degree necessary to achieve NASA's objectives without relieving the contractors of their mission responsibilities. The overriding concern is to assure, before launch, that all components of the configuration — engines, guidance, propellant flow systems, spacecraft and experiments — will function as designed in space. Here is the last opportunity to assure performance and it is available only once — the launch team never has a second chance to correct an anomaly regardless of where and how it got into the configuration.

Dr. Debus made a difficult personal decision shortly after the new Center organization was announced. Throughout the Saturn I launch operations period, he had filled two positions as Center Director and launch director. Realizing that he must divest himself of daily involvement in launch preparations, he selected Rocco A. Petrone as the launch director.

Mr. Petrone entered rocket development in 1952 at Redstone Arsenal, Alabama and was in the blockhouse for the first launch of the Army Redstone ballistic missile in 1953. He became a full-fledged member of the launch team in 1960 while on active duty as an Army officer. He was chosen then by Dr. Debus to become project manager for Saturn

and an even more powerful rocket called Nova which was later shelved in favor of the Saturn V vehicle. A graduate of the U.S. Military Academy, Mr. Petrone played in the line on the famous West Point football teams of the Davis-Blanchard era. He earned a master's degree in engineering at Massachusetts Institute of Technology.

Petrone's first tasks were to represent the Center in planning Complexes 34 and 37 with representatives of NASA Headquarters and the Marshall and Manned Spacecraft Centers. Later he became Apollo Program Manager for the Kennedy Center. In this position he coordinated resources and scheduled actions necessary to ensure that launch facilities met the requirements of the Saturn vehicles and Apollo spacecraft. The design of facilities also influenced the design of the flight hardware, and those facilities had to be ready for use when the flight stages were delivered to the Spaceport for final preparation and launch.

Mr. Petrone played a key role throughout the planning and construction of Launch Complex 39. To a very large degree it fell to him to supervise the design and evaluation of major elements of the mobile concept until the alternatives had been carefully weighed and decisions made that could, in fact, be translated into operational equipments like the crawler, the mobile launcher, mobile service structure, the assembly building and launch control center. He retired from active military service in 1965.

Following the successful Apollo 11 mission and after the U.S. Air Force recalled Lt. Gen. Samuel Phillips to head up the military space and missile development programs, Mr. Petrone was selected by Dr. Thomas O. Paine, NASA Administrator, and Dr. George E. Mueller, Associate Administrator, to succeed General Phillips as Apollo Program Director in Washington. He terminated his service at the Kennedy Center September 1, 1969.

Dr. Debus immediately named Petrone's deputy, Walter J. Kapryan, to succeed him as launch director. A native of Flint, Michigan, Mr. Kapryan attended Wayne University in Detroit and served as a B-29 flight engineer during World War II. He joined the Langley Research Center in September, 1947 and became a member of NASA's Space Task Group in March, 1959. He was appointed project engineer for the Mercury Redstone spacecraft and came to Cape Kennedy in 1960. He remained in a key position in the Mercury program, and next became responsible for Gemini spacecraft checkout equipment at KSC. He participated in the countdown of all 10 manned Gemini missions as well as the Apollo/Saturn IB and Saturn V missions. NASA honored his service in the Gemini program with two awards.

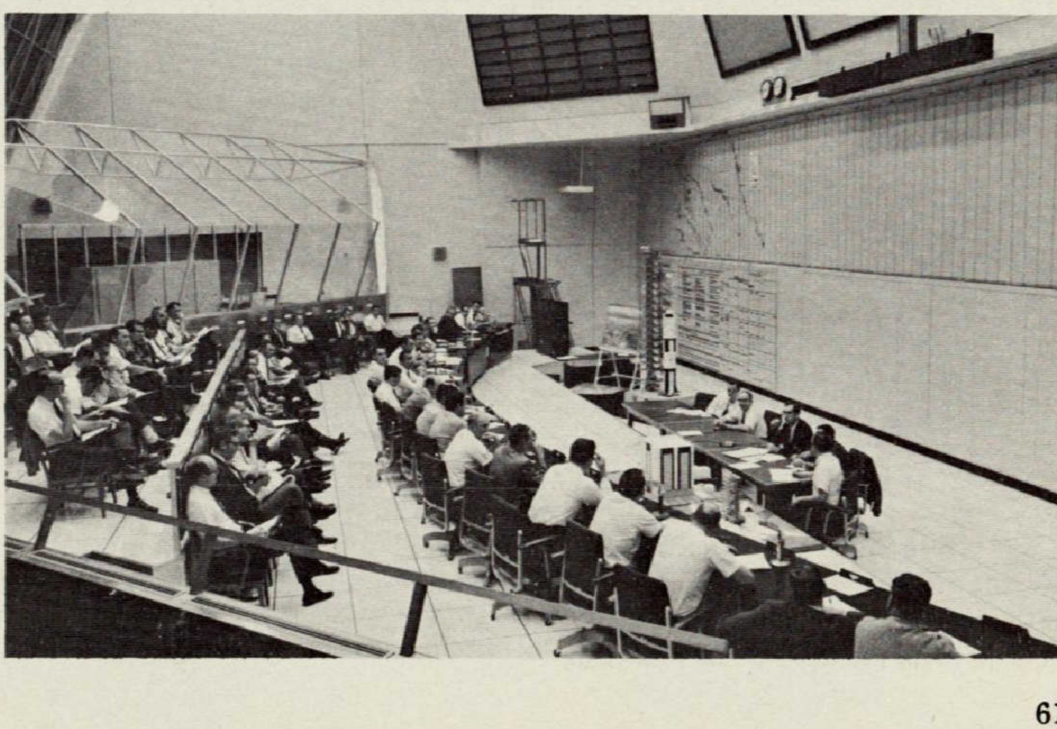
The KSC Launch Directorate has three principal departments:

—Launch Vehicle Operations for the Saturn rockets, directed by Dr. Hans F. Gruene who has been associated with Dr. Debus more than 25 years. He became a research engineer after graduating from the technical university in Braunschweig and joined Dr. von Braun's rocket development group in 1943. Dr. Gruene came to the United States in 1945 to assist in developing Army ballistic missiles.

—Spacecraft Operations, directed by John J. Williams, veteran of both the Mercury and Gemini programs, concerned with the Apollo command and service modules and the lunar module. Mr. Williams joined the Air Force Missile Test Center at Cape Kennedy after graduation from Louisiana State University with an engineering degree. He became a member of NASA's Space Task Group in 1959. This was the nucleus of today's Manned Spacecraft Center.

—Unmanned Launch Operations, directed by John J. Neilon, a mathematician who attended St. Anselm's College, joined the Naval Research Laboratory in 1948 and became a member of

Progress of launch preparations for Apollo/Saturn V vehicles is reviewed daily in Firing Room 4 of the Launch Control Center. Here contractor and Government planners and controllers check progress against plan and map out work schedules from the time vehicle stages arrive at the Center until launch.



the Vanguard team in 1955. He transferred to Cape Canaveral in 1957.

The Launch Directorate has overall responsibilities for checkout, assembly, test and launch of NASA vehicles and spacecraft on the Eastern and Western Test Ranges. Within each of the three main departments, faculty specialization is encouraged in such areas as launch instrumentation, electrical guidance and control, mechanical and propellant systems, flight and ground systems, launch vehicles and quality surveillance.

There are three other first line directorates whose chief function is to support launch operations requirements:

—Technical Support, headed by Raymond L. Clark, a West Point graduate with a master's degree in engineering from the University of Southern California, Mr. Clark became senior project engineer in 1954 at the Atlantic Missile Range for the Army's Redstone and Jupiter missile systems. His duties required daily contact with the launch team. Dr. Debus requested the Army to assign him to the Center in 1960, and he has remained ever since, retiring from military service in 1965. He participated in the planning and design of Complex 39 and handled other major assignments as special assistant to Dr. Debus before assuming his present office in 1964.

—Design Engineering, directed by Grady Williams, a graduate of Auburn University in electrical engineering, who joined the military rocket program in 1950 with an aerospace contractor. He became chief of the measuring unit of Dr. Debus' launch team in 1952, working at Huntsville and shortly afterward at Cape Canaveral. He was the deputy director of Design Engineering for three years prior to becoming its chief.

—Installation Support, directed by Frederic H. Miller, Air Force Major General, who commanded the Middletown, Pennsylvania Air Materiel Area before retiring from the military service and joining NASA in 1966. He is a graduate of Purdue University where he received an engineering degree and earned a master's degree from the University of Pennsylvania. From 1966 to 1967, when he assumed his present duties, he was deputy director of administration and chief of resources management for the Center.

The Technical Support Directorate manages and directs the maintenance and operation of all specialized test and launch facilities and related equipment, except launch vehicle stages and spacecraft and associated ground support equipment controlled by the Launch Operations

Director. The Support Director also represents the Center in program requirement relationships with the Eastern Test Range.

There are two major departments within the directorate — Information Systems and Support Operations. Karl Sendler, colleague of Dr. Debus more than 20 years, is the Information Systems Director. He holds a master's degree in electrical engineering from the University of Vienna. Mr. Sendler supervises telemetry, data acquisition, handling and distribution; commercial and scientific automatic data processing and calibration, and maintains a reference standards laboratory. Robert E. Gorman directs Support Operations including the maintenance and operation of test and launch support equipment, propellant logistics services, technical support shops and laboratories, and technical communications. He is a graduate of Kansas State University where he received a degree in mechanical engineering, and has been a member of the launch team 16 years.

The Director of the Executive Staff is Walter P. Murphy, a U.S. Naval Academy graduate who retired from the Navy in 1966. The Executive Staff manages the Center's executive communications and maintains a management status and review system.

Design Engineering, under Mr. Williams, provides continuing engineering support for facilities and ground systems. This is the NASA interface with the Corps of Engineers which supervised most brick-and-mortar construction projects for the Center. The directorate devises solutions to mechanical, civil and electrical-electronic requirements for existing or new launch facilities. D. D. Buchanan, Mr. Williams' deputy, previously served as chief of mobile structures during the design, fabrication and assembly of the Complex 39 launchers, the mobile service structure and the giant crawlers. C. T. Wasileski supervises the facilities and systems management group. Walter Parsons, a veteran of Mercury and Gemini programs, directs the systems engineering division while R. P. Dodd is chief of project integration.

Two men of many years' experience in launch operations are also assigned to this directorate, Mr. Albert Zeiler and Mr. T. A. Poppel. Mr. Zeiler is an engineer who was educated in Austria. Now chief of the Mechanical Systems Division, Zeiler's special competence in propulsion systems made him a key figure in the early Redstone and Jupiter days before automatic instruments became available. It was he who observed engine ignition through the blockhouse window to evaluate engine and fuel performance.

Mr. Poppel studied mechanical engineering in German technical institutions. As World War II neared its close, while at Peenemuende,

he was one of three men picked by Dr. von Braun to hide in a mineshaft the master drawings and data concerning the V-2 rocket to keep them out of hands of advancing Russian armies. He supervised much of the design of mechanical equipments for Launch Complex 39.

The Director of Administration is George A. Van Staden, who was executive officer of the National Institute for Mental Health 10 years before joining NASA. Mr. Van Staden had previously been engaged in the administration and budgeting of research and development funds at the National Institutes of Health. He earned a master's degree in administration from George Washington University.

The Directorate supervises procurement, contract negotiations, personnel administration, and a Center-wide resources management system. Its staff manages institutional resources including funds for administrative operations which amounted to $97,445,000 in Fiscal Year 1970. Related construction funds, which ran into hundreds of millions when 7,000 tradesmen built the Spaceport, have been reduced to modest amounts. Resources and requirements specialists in each first line directorate track the utilization of their allocated funds.

Apollo Program Conference Room in KSC Headquarters where the total effort required to prepare and launch space vehicles, including ground support, is continually reviewed, updated and scheduled.

Early in 1970, Dr. Debus moved to concentrate the Center's future planning activities in a new Directorate headed by G. Merritt Preston. Andrew Pickett, formerly a key engineer in the launch operations team, joined Mr. Preston as deputy. With a small, permanent staff, augmented when required by experts loaned by other KSC organizations, this directorate works closely with the Manned Spacecraft and Marshall Space Flight Centers and NASA's Office of Manned Space Flight in formulating the manned space program for the next several decades.

Program offices keep the Center in phase with the continuing Apollo lunar exploration and Skylab programs, maintaining liaison with counterpart offices in Houston and Huntsville and the Manned Space Flight Office in NASA Headquarters, which coordinates manned space activities. Rear Admiral R. O. Middleton, USN, served as KSC Apollo Program Manager from 1967 to 1969, succeeding Major General John G. Shinkle, USA, retired, who served in this capacity following Mr. Petrone's designation as Director of Launch Operations.

When Admiral Middleton returned to fleet duties after the Apollo 11 event, he was replaced by his deputy, Edward R. Mathews who came to Cape Kennedy in June 1958 with the Missile Firing Laboratory group of the Army Ballistic Missile Agency. He became a member of the project coordination staff in NASA's launch operations directorate in 1960. A graduate of George Washington University, he served in the Air Force during the Korean War. He provided program direction for construction, activation and operation of the Saturn launch complexes prior to appointment as the deputy Apollo Program Manager. Mr. Mathews left the Space Center in June on a year's leave having been appointed a Sloan Fellow for graduate study at Massachusetts Institute of Technology.

Brigadier General Thomas W. Morgan, who was operations director of the Air Force Manned Orbiting Laboratory program, joined KSC as manager of the Skylab effort, formerly called Apollo Applications since it will utilize flight stages designed for Apollo for new undertakings. A graduate of Auburn University where he received an engineering degree, General Morgan also attended the University of Michigan where he pursued graduate studies. His deputy is a former Air Force officer, Robert W. Hock. During the absence of Mr. Mathews, the two program offices will function under General Morgan in consolidation which will make more effective use of the experienced staff. NASA will utilize a Saturn V vehicle in 1972 to launch an experimental space station, or Skylab, which will be visited and operated by three crews of Apollo astronauts in 1972 and 1973.

While the program office oversees gross allocations of funds and manpower, each directorate manages the dollars essential to perform assigned tasks and directly supervises the contractors engaged in them. The Center's budgets, or annual spending programs, reflect the rate of growth which occurred up to September 1968 and the gradual reduction in spending that accompanied the slowdown in Apollo launches after Apollo 11 achieved the first successful lunar landing. Since the launch organization was formerly supported by the Marshall Center, it did not begin to budget separately until mid-1963 for administration, operations, research and development as NASA's Launch Operations Center.

Other NASA Centers, Marshall and Goddard for example, transfer funds for certain launch support and facility modifications conducted at the Kennedy Center. Total NASA expenditures at this location peaked at $525,000,000 in FY 1969 and have been reduced to approximately $350,000,000 in FY 1971.

FY 1960-1971 Budgets
(Millions of dollars)

Fiscal Year	Research & Program Management	Research & Development	Construction	Total
1960			$ 4.0	$ 4.0
1961			27.7	27.7
1962			110.3	110.3
1963	$18.8	$ 10.1	311.3	340.2
1964	29.8	57.1	275.4	362.3
1965	40.8	70.5	88.5	199.8
1966	81.9	133.7	6.9	222.5
1967	92.8	228.0	35.7	356.5
1968	93.6	374.1	16.8	484.5
1969	95.8	386.3	8.0	490.1
1970	97.4	269.6	15.6	382.6
1971	98.2	226.8	6.5	331.5*

*Requested

While Apollo Manager, Mr. Petrone organized Site Activation Boards for Complexes 34, 37 and 39, charged with the task of bringing these facilities to operational status in phase with the arrival of flight vehicles. Both Complexes 34 and 37 required extensive modifications to fit the Saturn IB rockets with Apollo command, service and lunar modules.

At Complex 39 the Board applied the program evaluation review technique, or PERT system, which has enjoyed wide success in Government and industry. PERT recorded 37,000 different events on which progress was periodically measured in a computerized system. Eighteen contractors engaged in preparing the complex for the Apollo/Saturn V vehicles furnished 150 personnel to maintain daily reporting for those

events for which each contractor was responsible. At peak effort, 40,000 individual end items of equipment furnished from Government or industry sources were constantly monitored to ensure they would be available when required. Colonel Donald Scheller of the Air Force, who acquired specialized experience in site preparation for the Minuteman inter-continental missiles, ran this operation at Complex 39.

Four staff offices reporting to the Center Director furnish specialized assistance to the organization in legal matters, quality assurance, public affairs and safety.

As the Center has evolved from a small, Government launch team to a multi-mission, integrated Government-industry enterprise, the organizational arrangements have been changed in phase with its growth. More evolutionary development should be anticipated in future years as the space program changes as a result of new information garnered from unmanned and manned operations and as improved transportation systems become available and mature.

The Center's technical missions require a wide range of highly specialized skills, some of which had not even been described in Government position classifications 10 years ago.

Half of the Center's employees are college graduates. There are 1,206 engineers in the Civil Service work force and 468 technicians, some of whom have qualifications almost equal to those of the engineers. Attesting to their depth of experience in launch technology, 1,170 of the Center employees have 10 or more years service while 388 have worked over 20 years for the Government.

The range of engineering and scientific specializations within the professional group, and the numbers of each type, are as follows: Technical management, 232; experimental facilities and equipment, 127; flight systems test, 120; measurement and instrumentation systems, 113; launch and flight operations, 92; data systems, 70; quality assurance, 26; electrical systems, 60; tracking and telemetry, 22; telemetry systems, 30; telecommunications, 34; control and guidance systems, 44; electrical experimental equipment, 19; propulsion systems, 21; flight systems, 7; reliability, 12.

Fewer specialists are employed in life sciences project management, meteoroid studies, liquid propellant systems, basic properties of materials, measurement standards and calibration, tracking systems, environmental control, flight mechanics, experimental facility techniques, project management and stability control and performance.

The Civil Service complement includes almost 700 women, some of whom occupy positions of considerable responsibility in relatively un-

usual career fields. There are specialists in contract negotiations, data systems, measurement and instrumentation systems, computers, experimental facilities and equipment, materials, inventory management, technical information, data requirements, procurement, price analysis and accounting. In all, the Center has 70 different categories of jobs capably filled by women.

Twelve of them have been in NASA service almost as long as the agency's history and several of them were employed in the predecessor launch organization, the Missile Firing Laboratory, before NASA came into existence. Miss Elsa Borgman, formerly secretary to Dr. Debus, has been secretary to Karl Sendler, Director of Information Services, since 1959. Others include Lali Russell, the KSC Librarian who held the same position in the Missile Firing Laboratory; Pauline Moncrief, the Center's cashier; June Carson, administrative assistant to the Launch Operations Directorate; Alberta Duggins, classified document control clerk; Annie Taylor, supervisory administrative specialist in Design Engineering; Natalie Spielman, secretary in documentation; Tony Revels, office service supervisor; Shirley Fergerson, secretary to Dr. Debus and Bobbie Clark, secretary to Robert E. Gorman, Director, Support Operations. Among other long time employees are Marlene Davis, a personnel employee since 1958; Mary Driver of personnel who joined NACA in 1956 and later became a NASA employee; and Bobbie Miller, protocol, who joined NASA in 1959.

The presence of members of the launch team of the 1950s was of incalculable value and a stabilizing influence during the rapid expansion of the Center. They have built up a wealth of expertise during association with military missile systems and space launch vehicles ranging in size from the Redstone, 58 feet tall and developing 78,000 pounds thrust, to the powerful Saturns which are the heavy boosters for manned space flight.

They have learned how to work with hazardous fuels. They participated in the development of launch facilities and techniques, assembly, test and countdown procedures. They have trained military launch crews for the U.S. Army, the U.S. Air Force and NATO allies who deployed the rocket-powered weapons systems which passed flight testing in their capable hands. They indoctrinated and trained contractor personnel who conduct the launch preparations under their supervision.

As the Center has grown, so has their competence. Many of these launch team veterans occupy key positions in the first-line operating directorates where their unique knowledge can be put to the most effective use. Some are identified in the following pages, others are named earlier.

Robert E. Moser joined the team as an Army specialist in the Redstone period and became a test conductor. He coordinated launching of the first U.S. satellite, Explorer I. Today Mr. Moser manages the Test Planning Office for the Director of Launch Operations. E. P. Bertram is chief, requirements and resources.

More of this pioneering group work with Dr. Hans F. Gruene in the Launch Vehicle Operations directorate than in any other Center element. They have counted down and launched rockets over the last 15 years and they are the mainstay of the Saturn team. The group includes I. A. Rigell, Deputy Director, Launch Vehicle Operations; Milton Chambers, chief, gyro and stabilizer systems; T. D. Pantoliano, deputy chief, mechanical and propulsion systems; C. A. Whiteside, chief, guidance and control systems; C. W. Dowling, LVO systems integration representative; C. A. Turner, deputy chief, electrical, guidance and control systems; J. J. Fitzgerald, chief, measuring; A. E. Jorolan, chief, ground measuring; M. D. Edwards, chief, launch instrumentation systems; G. D. Ball, chief, stabilizer ground systems; C. D. LaPorte, chief, stabilizer and accelerometer systems; J. T. Humphrey, chief, propulsion and vehicle mechanical systems; William Jafferis, assistant to the Deputy Director for engineering; J. M. Twigg, assistant to the Director for Skylab and future studies program; H. G. Crunk, transportation and handling, launch vehicle stages; and J. K. Davidson, deputy chief, electrical systems.

In the Information Systems directorate, besides Karl Sendler, the Director, there are Dr. R. H. Bruns as chief, data systems; R. L. Wilkinson, chief, measurement systems; W. G. Jelen, chief, NASA/KSC data office; L. F. Keene, chief, measurement and instrumentation analysis; D. B. Varnado, chief, telemetry; Carlton Scheetz, telemetry; D. D. Collins, data systems; Francis Byrne, chief, radio frequency systems; and R. A. Browne, chief, OIS and telecommunications.

The Director of Support Operations, R. E. Gorman, is a member of the group as are G. T. Thomas, planning and contract support; B. E. Stimson, technical assistant to the Director; J. T. Campbell, chief, support scheduling and coordination; and C. S. Moses, chief, operations division.

The Design Engineering Director, G. F. Williams, another member of the group, has T. A. Poppel, advanced engineering and planning branch; Vince Gottuso, mechanical design; W. W. Kavanaugh, deputy chief, project integration office; D. R. Stubbs, chief, audio; Albert Zeiler, chief, mechanical design; J. R. White, chief, electrical-electronics design; R. P. Dodd, chief, project integration; J. H. Deese, chief, electronics; and W. L. Cannon, chief, electrical.

There are many other key personnel today at KSC whose ties to the

space program make them long-time veterans. For instance, C. C. Parker, now the Deputy Director, Installation Support, came with the original team from Huntsville, Ala. D. W. Hardin of this directorate is now chief, test support management office, and J. F. Russo is chief, documentation division.

P. A. Minderman is the Deputy Director, Technical Support and R. T. Gwinn is assigned to Technical Support's range support analysis branch. A. J. Pickett is Deputy Director, Center Planning and Future Programs, and J. P. Claybourne, special assistant to the Director for technical matters.

E. R. Mathews has been identified with the Saturn vehicles since the initiation of the program — he was the Apollo Program Manager. Bert Greenglass, another former Army specialist who joined the team while a soldier, was the chief, Apollo program control office until his transfer to NASA Headquarters at the end of 1967. B. W. Hursey is chief of personnel. R. F. Heiser serves as technical assistant to Dr. Debus as he has since the launch team was formed in the early 1950s. J. S. Loy, formerly the Director's protocol representative, is assistant to the Chief of Public Affairs, Gordon Harris, who was here as Maj. Gen. J. B. Medaris' public information officer at the launching of America's first satellite, Explorer I, in 1958.

One of the striking contrasts between the Space Center and its predecessor organization can be found in the changing role of the Government engineer. Once he worked directly with flight vehicles, spacecraft and ground support systems. He has become a manager removed from direct association with the hardware, who supervises or instructs the aerospace contractors preparing stages for launch, operating the ground-based systems designed by the Government cadre, or providing supporting services.

He is a member of the small team of Civil Service personnel who acquired deep knowledge of technology relating to launch operations first with the Army, Air Force or Navy, then within NASA. Collectively, the original Debus-directed team, the former Goddard Space Flight Center launch group, and the Florida Operations team of the Manned Spacecraft Center represent more competence in this technology than has been accumulated by any other group in the Free World. It is a national resource of first magnitude.

To the extent that the demands of launch operations schedules permitted, and particularly since they joined NASA, many of these men and women have pursued specialized technical studies and thus acquired knowledge in their disciplines or earned graduate degrees. They have

DDE

GETTYSBURG
PENNSYLVANIA 17325
Indio, California
January 31, 1968

Dear Dr. Debus:

Ten years ago today, you, and members of the U. S. Army's Missile Firing Laboratory, launched the Explorer 1 satellite and also this Nation's entry into man's most challenging period of exploration.

Appropriately, Explorer 1 provided the first data about the hazardous radiation belt surrounding the earth, information which has greatly aided in the design and development of both manned and unmanned spacecraft.

Your outstanding accomplishment also chartered America's unfaltering pledge to share with men of all nations technology obtained through the peaceful exploration of space. The National Aeronautics and Space Administration, the agency with which so many of the original Explorer launch team is now associated, carries on this important responsibility, one which has led to the development of numerous innovations for enhancing our daily lives.

Though Explorer 1 no longer transmits from its outerspace "berth," it serves as a silent sentinel, ushering new American space accomplishments along the first leg of their varied space missions. The Explorer 1 launch team's dedication and ingenuity also is evident nowadays and, hopefully, will provide an inspiration for future space engineers in years and centuries to come.

Sincerely,

Dwight D. Eisenhower

Dr. Kurt H. Debus, Director
John F. Kennedy Space Center, NASA
Kennedy Space Center, Florida 32899

Former President Dwight D. Eisenhower transmitted this message to the Center Director on the occasion of the 10th anniversary of the first U.S. satellite, Explorer 1.

acquired broad understanding of the interrelationships among their various specializations, the better to appraise the effect of changes and modifications across the total spectrum of complex vehicle and spacecraft systems. This kind of competence alone has tremendous significance in the launch environment which is the point of maximum stress and maximum hazard. Through the years of shared effort, they have earned mutual respect that is clearly evident in the exchange of information and opinion in their planning meetings. Their quiet assurance is built upon a solid foundation of competence and confidence in one another's judgment and ability to perform.

Dr. Debus enjoyed an informal reunion January 31, 1968 with members of the original launch team on the occasion of the 10th anniversary of the first U.S. Earth satellite, Explorer 1. The team gathered at Launch Complex 56, long since obsolete and being preserved for historical purposes, where they conducted Army missile launchings prior to 1960. Nearby stood an exact replica of the Jupiter C vehicle which carried Explorer into Earth orbit. On March 31, 1970, Explorer died as it reentered the atmosphere over the South Pacific. The tiny 30.8 pound spacecraft discovered the Van Allen radiation belts in space and provided the first American reply to the Soviet Union's Sputniks. At the same complex the pioneers saw a duplicate of the Mercury Redstone vehicle in which they launched the first U.S. astronaut, Alan Shepard, in May 1961. Shepard will command Apollo 14.

In that setting, Dr. Debus spoke to his teammates with a note of sadness as he mentioned the names of Fred Merritt, Robert Heller, Melvin Bowman, and Jack Froelich who had passed on in the intervening years. He recalled, too, some members who had since retired: Howard Russell, John Minter, James Rivers and James Pittman. He vividly described what he and Dr. Hans Gruene found on their first visit to Cape Canaveral in 1952 — "an old, abandoned restaurant, windows nailed up, occupied by a Colonel Heiman of the Air Force. We began working in shacks which leaked every time it rained, and it rained often."

Tracing the growth of his organization, Dr. Debus remembered that in 1961 when the national decision was made to launch men to the Moon, the team numbered about 300 Government personnel supported by some contractors. Then and there, the concepts had to be formulated promptly for a Government-industry team capable of accomplishing these unprecedented tasks. It is the team which comprises the Center today.

IX

Moment of Truth

FOR the men who planned the Apollo program in 1961, and for thousands of others who designed, fabricated and tested the space vehicle and spacecraft, for countless thousands who fashioned precision parts and components, who produced the super-cold fuels and oxidizers, who built the Spaceport, the morning of November 9, 1967 will always be a memorable occasion.

For the people of Kennedy Space Center, it would be the ultimate test of their years spent in planning and construction; recruiting, training, and organizing the largest launch team that had ever been assembled in this country. It would be the first launch for some members of the team, but without exception every man realized that he was dealing with the most powerful rocket thus far developed by the United States — an incredibly complicated assembly of metal, wire, plastics and other materials, fueled with 6,000,000 pounds of oxidizer and propellants, adding up to far greater mass than had ever before been lifted from the Earth by the propulsive force of rocket engines.

What was to happen that morning would either verify, or open to question with potentially adverse impact upon the space program:

—the mobile launch concept embodied in Complex 39 launch operations

—the Saturn V vehicle as the transportation system for manned journeys to the Moon which must hurl 285,000 pounds into orbit

—the Apollo spacecraft as the carrier for the Moon-bound astronauts and its ability to withstand the searing heat on reentering Earth's atmosphere while traveling at 25,000 miles per hour

—the worldwide NASA tracking and communications network essential to link the Apollo spacecraft with its earthbound flight controllers and the Department of Defense recovery fleet of aircraft and ships.

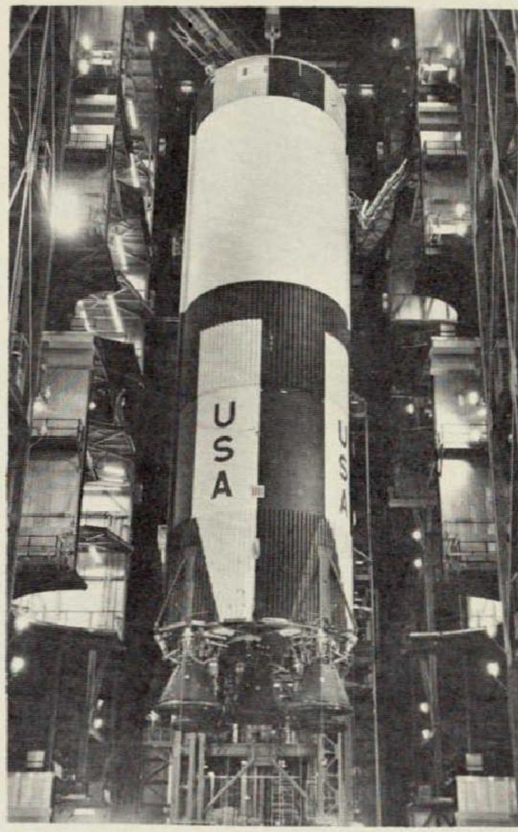
The events of November 9th had been in the making six years. Out of the millions of newspaper readers, probably few recalled reports of a talk by Dr. Wernher von Braun, Director of the Marshall Space Flight Center, a few months after President Kennedy announced the lunar mission as a national goal. Dr. von Braun described an advanced Saturn rocket, the booster stage of which would be powered by three engines. The basic engine, called the F-1, would generate 1,500,000 pounds of thrust, and had been under development for NASA by North American Aviation's Rocketdyne Division since October 1958. By late Fall of 1961, design and feasibility studies had been completed. Marshall's engineers toyed with novel names for the vehicle. For a while they considered "Krona" but later settled on Saturn V when the final configuration included five rather than three 1,500,000-pound thrust engines.

After competitive screening of potential contractors, NASA began negotiating with North American Aviation in September 1961 for design and fabrication of a second stage generating 1,000,000 pounds thrust with five J-2 engines and burning liquid hydrogen fuel. In December 1961 Boeing was selected to build the 7,500,000 pounds thrust first stage propelled by jet fuel. Later that month the Douglas Aircraft Company was chosen to furnish the third stage developing 200,000 pounds thrust with a single engine, the J-2, burning liquid hydrogen. This was essentially the same as the second stage employed in the Saturn I vehicles. The Marshall Center supervised all of these vehicle contractors.

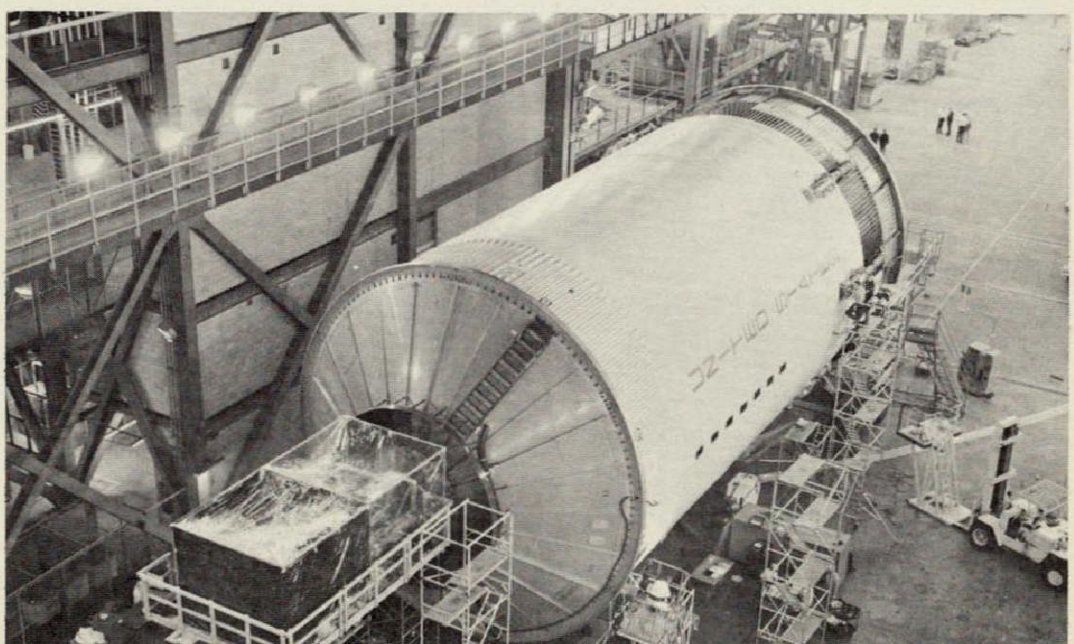
In August 1962 design of the instrument unit was approved. Marshall initially undertook to build this stage; later, a contract was awarded to International Business Machines and Marshall became the supervising agency.

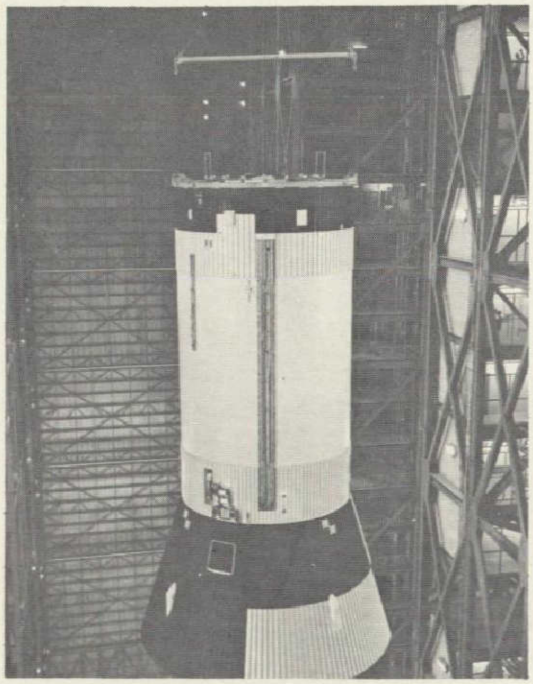
While the space vehicle contracts were being negotiated, the Manned Spacecraft Center was contracting with North American Aviation to provide the Apollo service command modules. Grumman Aircraft Engineering was selected to fabricate the lunar modules which would be true spacecraft since, once launched, they are not designed to return to Earth and will function only in the space environment and on the lunar surface.

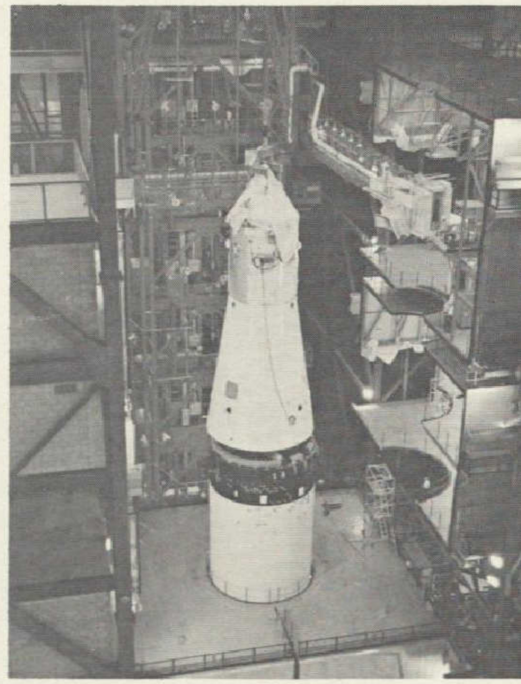
Concurrently, and pointing toward that test of fire six years away, Kennedy Space Center planners undertook to design the facilities required to accommodate the launch vehicle and spacecraft which had to be ready for use when the stages were ready for launch. The Congress appropriated funds to NASA for construction of these facilities, and others in Mississippi, Alabama, and on the West Coast to permit static testing every stage before delivery to the launch center. The Canaveral



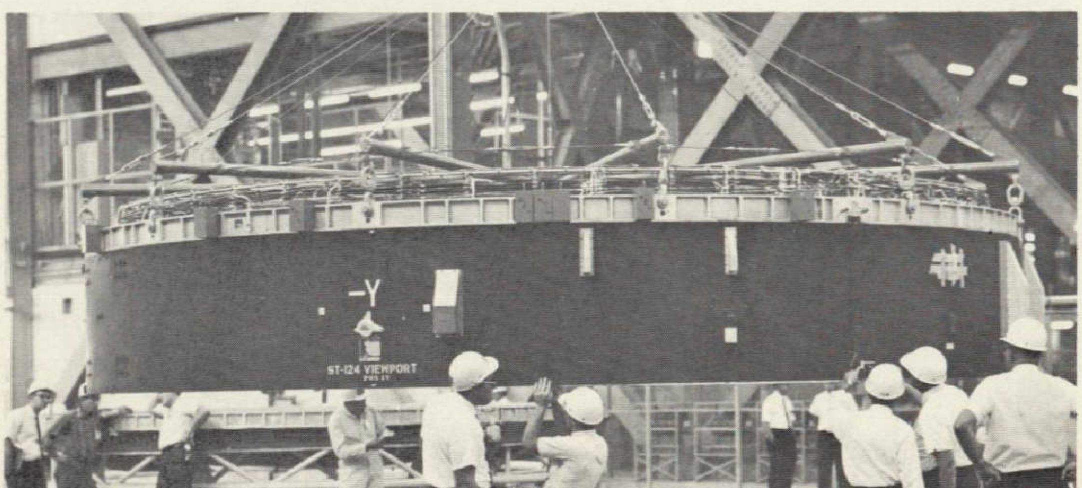
Right: First stage of Saturn 501 being lowered gently to deck of Mobile Launcher by powerful crane. Below: Second stage undergoes careful inspection in VAB transfer aisle low bay area before mating with first stage.







Upper left: Crane lowers third stage of Saturn 501 to permit mating with the second stage. Upper right: Apollo spacecraft in place, resting atop the instrument unit which cannot be seen because of the work platform. Below: The instrument unit which guides the space vehicle through powered flight.



District, Corps of Engineers, became Kennedy's construction agent, awarding the contracts and supervising their execution.

It is a tribute to American ingenuity and hard-earned experience acquired in managing other large-scale enterprises that all of these actions could begin at approximately the same point in time, at locations thousands of miles apart, and that the end products would eventually come together, for the first time, at the launch center, ready for mating and in phase with the schedule laid out years before.

Since the earlier Saturns of 40,000-pounds payload capability had been designated the 200 series, NASA elected to number the larger Saturn V's in the 500 series. Consequently, the first to be launched became Apollo Saturn 501, and since this was the fourth Apollo spacecraft, the mission became Apollo 4.

Boeing began work on the booster, or S-IC stage, February 15, 1963; North American Aviation started the second, or S-II stage, January 5, 1964 and the Apollo spacecraft December 1, 1964. Douglas initiated work on the third, or S-IVB stage, June 1, 1964, and IBM started to fabricate the instrument unit November 20, 1965.

During that same period, the Vehicle Assembly Building was being framed, the mobile launchers were being assembled, piece by piece, cement was being poured at the launch pad, and the crawlers were being assembled at Kennedy.

The flight hardware coming off production lines and static test stands began to arrive at the Center in mid-1966. The S-IVB stage was flown in by a Super Guppy aircraft in August followed 10 days later by the instrument unit. The booster stage arrived by ocean-going barge September 12, 1966 and the lunar module test article — representing the shape and weight of the spacecraft — reached Kennedy later in the month. Apollo service and command modules were flown in from the West Coast just before Christmas 1966.

The launch team began stage erection and checkout operations in Bay 1 of the Vehicle Assembly Building in October 1966. Since the second, or S-II stage, had not yet reached the Center, a huge metal spindle, or spacer, of exactly the same proportions, was employed in the stacking process to take its place. The flight stage arrived by barge in January 1967. After initial checkout, it was placed atop the booster stage, the spacer was removed, and the process of completing the stage assembly went on. Launch crews continued the painstaking verification procedure under the careful scrutiny of the engineers and technicians manning consoles in Firing Room 1 of the Launch Control Center.

In late June 1967 the S-II contractor, North American Rockwell, advised NASA that cracks had been detected in a similar stage fabri-

cated after the one which was assembled in AS-501. It was immediately decided to remove the stage and subject its welds to X-ray examination in the transfer aisle of the VAB. So the powerful cranes lifted off the upper stages, and placed the suspect stage gently down in the aisle. By July 9th, the X-ray testing had been completed, the stage was pronounced flight worthy and returned to its position in the AS-501 configuration.

The vehicle was ready for electrical mating July 25th. From there on, preparations moved smoothly towards a simulated flight test August 18th. The test was completed without major problem. Next, the launch team had to install ordnance, or explosive charges, in the Saturn V. These are fired automatically in flight to separate stages as they burn out. While ordnance installation was in progress, other work locations had to be found for 1,400 persons usually employed in the tiers of offices close to Bay 1.

At nightfall August 25th, the crawler moved into Bay 1, jacked up the mobile launcher and launch vehicle, and prepared to transfer the 12,000,000-pound assembly to the firing site. Early in the morning of August 26th, the towering mass of the mobile launcher slowly emerged from the Vehicle Assembly Building. The rising sun illuminated the scene as the crawler lumbered past the Launch Control Center — Saturn V's journey into space began at something less than one mile per hour.

Once the mobile launcher had been secured atop Pad A, the crawler moved the mobile service structure into position and its work platforms enclosed the upper portion of the configuration. Pad crews mated electrical, pneumatic, propellant and oxidizer lines between the pad facilities and launch vehicle. The computer in the launcher's base maintained steady communications with the computer in Firing Room 1 where the round-the-clock monitoring continued. As problems were detected, they were speedily corrected. For example, four actuators in first stage engines were replaced early in September.

Marshall Space Flight Center engineers worked side by side with the Kennedy launch team, assisting in preparing the vehicle which they had designed. In mid-September, bad weather hampered flow tests of the liquid hydrogen fueling system. Winds of 45 to 50 miles per hour were measured on the launcher. Lightning and heavy rainfall occurred the following week, postponing the countdown demonstration test, possibly the most critical of the multiple tests carried on during the prelaunch preparations. The CDDT, as it is called, requires a complete rehearsal of the actual launch including the fueling of both spacecraft and rocket, short only of starting the engines.

Three times between September 27th and October 13th, the CDDT

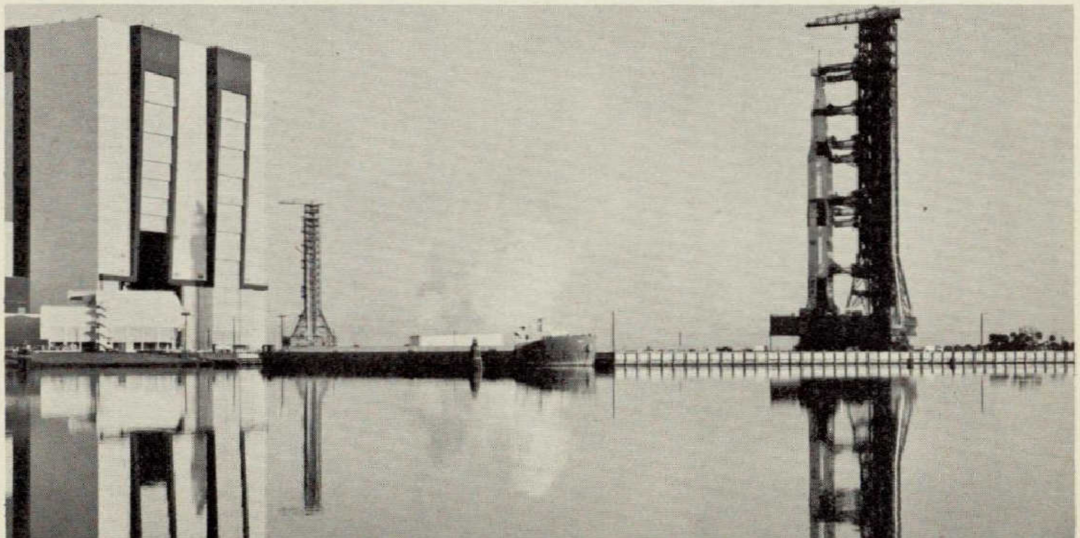
was begun and subsequently temporarily halted by a succession of annoying problems — although problems had been anticipated in this first experience with a new vehicle, new ground equipment and a new launch team. Items which functioned normally in one countdown rehearsal suddenly became problems during the next. They included cables, fuel cells, a compressor, computers, stage batteries, a helium regulator, a probe measuring the fill rate of liquid oxygen, and broken sump baffles in the S-II stage. Baffle plates had to be removed and replaced.

When the CDDT was finally completed, Center management felt that a major step had been accomplished — the 450-man crew in Firing Room 1 and the men working on the pad had learned how to phase their effort uniformly over a three-shift working day and the mutual confidence developed between and among the Government-industry members became plainly evident. A series of interface tests ensued to verify hard line communications between flight controllers in Houston, Texas, and launch controllers at Kennedy. Next came the flight readiness test, conducted over a period of two days.

The 104-hour countdown began October 30th when the spacecraft was fueled. Liquid hydrogen was next pumped into the space vehicle tanks. Then the RP-1 or jet fuel was loaded into the booster tanks and the vehicle was ready for the terminal portion of the countdown.

The men directing the preparations gathered for the customary launch weather briefing upstairs over Firing Room 1 at 11:30 P.M.,

Apollo 4 space vehicle being transferred to launch site August 26, 1967.

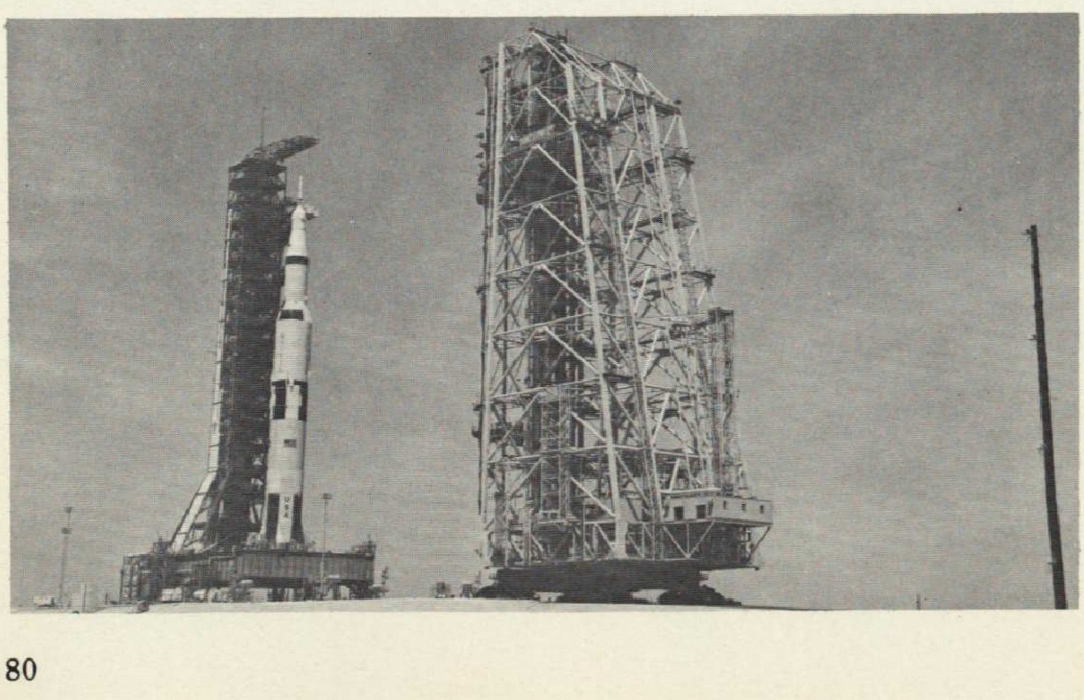


November 8th. Dr. Debus, Paul Donnelly, test conductor; Rocco Petrone, director of launch operations; Ray Clark, director of technical support; Major General Samuel Phillips, USAF, chief of NASA's Apollo program; Rear Admiral R. O. Middleton, Apollo manager at Kennedy, and others were in the small group.

The weather forecaster could see no bad weather on the local chart; however, wind velocities November 8th had been marginal and the configuration could not be launched if there was a steady wind force of 28 knots. The briefer employed weather reconnaissance charts developed by ESSA satellite — one of those launched from Cape Kennedy by KSC. He predicted that maximum gusts would not exceed 26 knots the next morning at liftoff time. The weather in Atlantic and Pacific Ocean recovery areas was not the best — high seas were running — but recovery forces had advised they could operate as planned. So it was decided to proceed with the terminal count and look at the wind situation again later in the morning when the launch might still be delayed if necessary. The forecaster firmly stated that the winds would increase after 7 A.M., November 9th.

Pre-planned holds were provided in the countdown, one of six hours duration at T minus six and one-half hours, and another of one and one-half hours at T minus four hours. Some of this reserve time was consumed when a scratched seal was discovered in the Saturn V that had to be replaced. Another two-hour hold became necessary to check out the range safety command system.

Crawler carries Mobile Service Structure to pad.



The count proceeded until 3 A.M., November 9th when the clock was stopped for 60 minutes in order to reach T minus zero at 7 A.M. when there would be ample light for cameras recording every event on the launch pad and the behavior of the vehicle from ignition until it disappeared from camera view down range.

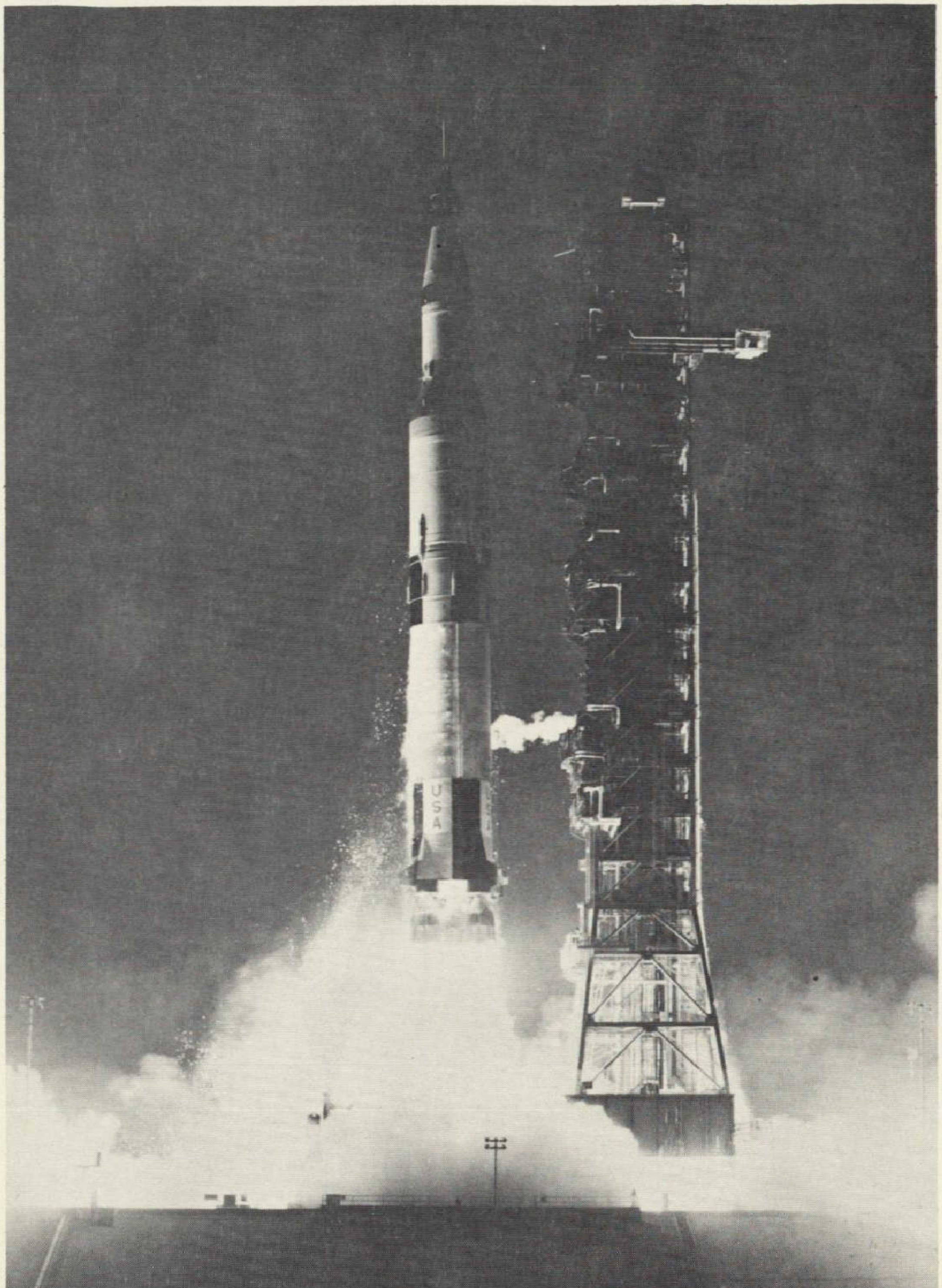
During the early hours, the top managers of Apollo took up positions in an observation bay in Firing Room 1. They included Dr. George Mueller, Associate NASA Administrator for Manned Space Flight; General Phillips, Maj. Gen. J. D. Stevenson, mission operations director; Dr. von Braun, Dr. Robert Gilruth, Director, Manned Spacecraft Center; Admiral Middleton; Capt. J. K. Holcomb, flight operations director; D. K. Slayton, Director of flight crew operations of MSC; and other representatives of Marshall and Kennedy Center management. Dr. Debus sat beside Rocco Petrone at the launch director's console in the firing room.

Exactly at 3 A.M., the clock was released. It tolled off the hours, minutes and seconds without interruption as the count inexorably proceeded toward ignition. At 3 minutes and 10 seconds prior to T—0, the computers took over the countdown — one in the Firing Room communicating with the other in the mobile launcher base, taking measurements, verifying systems in such numbers and at such speeds that the human brain could not possibly keep pace and must rely on the incredibly rapid response capacity of the computers.

Ignition occurred exactly on schedule 8.9 seconds before liftoff. Six seconds later, the giant engines had built up to 90 per cent thrust and the holddown arms constraining the rocket to the launcher deck slowly released at 7:00.01 A.M. Eastern Standard Time — or, as the official launch time is recorded, at 12:00:01 Greenwich Mean Time. Saturn V had begun its journey.

While 500 observers looked on in awe at the press site, and radio and television commentators described the scene to millions watching and listening in their homes, autos, or work locations, the huge swing arms connecting the umbilical tower and rocket swung clear as Saturn V began to move. Although weighing many tons, the arms were in retracted position against the tower in 4.5 seconds. AS-501 required less than 10 seconds to climb the 450 feet necessary to clear the tower. Dr. von Braun commented later, "They were the longest 10 seconds of my life."

At an observation site north of the Vehicle Assembly Building, 700 distinguished guests of NASA stood on bleacher seats or the sandy terrain. They broke into spontaneous cheers as the rocket majestically thundered into the dawn sky, its thunder shaking the earth. Governor Claude Kirk of Florida, wearing the yellow slicker of a Florida highway



Precisely on schedule, Apollo 4 lifted off at 7:00 A.M., November 9, 1967.

patrolman against the morning chill, cheered with the other observers.

Five miles to the south in the industrial area of the Spaceport, thousands of employees who drove in early to see the launch, and 1,400 wives invited for the occasion, joined in the cheering. Elsewhere, along the ocean beaches, highways and causeways, more thousands of onlookers watched the Saturn V and could plainly see burnout of the first stage and ignition of the second stage nearly 40 miles out over the Atlantic Ocean.

Looking on from Firing Room 3 of the Launch Control Center were more NASA guests, among them the presidents and board chairmen of Apollo contracting firms as well as distinguished scientists and military officers. Dr. Robert Seamans, the Deputy NASA Administrator, whose support helped bring Apollo into being, looked on as did Dr. Homer Newell, NASA Associate Administrator for Space Sciences and Applications, and others from the agency's headquarters.

As General Phillips later described the performance, it was a "textbook flight." Each stage, in turn, performed so closely to the predictions of Marshall and Manned Spacecraft Center engineers that time deviations from nominal were measured in seconds. Official post-launch assessments were replete with comments that "the stage performed very satisfactorily," which is ultimate praise from rocket perfectionists. The damage to the launch pad and equipment resulting from blast and the engines' flame was minimal.

Later, when talking to the press, General Phillips summarized the event in these terms: "I've been through a lot of countdowns. I was tremendously impressed with the smooth teamwork that this Government-industry team put together. It was smooth, it was professional, it was confident, it was perfect in every respect. It was a powerful operation — you could almost feel the will with which it was being carried out.

"This was, I believe, the most powerful rocket, perhaps the most powerful machine in terms of energy per second, that has ever performed. You could almost feel the power of the launch team during the night and on through the early hours of the morning and the last minutes and seconds of the countdown."

He smiled as he observed, "I know you got shaken up a little bit out here. The Launch Control Center shook, too, and I call that the operational shakedown. We were covered with plaster dust which shook out of the concrete structure."

Responding to the Marshall Flight Center's flight plan, programmed into the instrument unit, without human intervention, the giant vehicle steered a true course eastward over the Atlantic. The first stage burned out at 150.8 seconds as planned. The vehicle had attained 39.3 miles

altitude and was traveling 6,024.6 miles per hour. Cameras positioned in the second stage recorded on color film the smooth separation as the booster, 100 miles away from the pad, fell back and was destroyed by the friction of Earth's atmosphere as it fell. Air Force pararescue personnel recovered cameras and film after they were jettisoned from the vehicle.

At burnout of the second stage, the velocity had increased to about 16,000 miles per hour. Then, as the stages separated, the third stage engine flamed into life and increased the speed to 17,500 miles per hour at an altitude of 118.6 miles — Saturn V had carried a satellite weighing 285,000 pounds into orbit. This exceeded the total weight of the Atlas rocket and Mercury spacecraft which carried Astronaut Walter Schirra on his first flight in 1962. Schirra was among the observers in Houston during the Apollo 4 mission.

The spacecraft's propulsion system burned for 16 seconds, raising the apogee to 9,767 nautical miles. It was then steered into a reentry course, and the engine was fired once more for four and one-half minutes to drive the capsule back into the atmosphere at 25,000 miles per hour — the same velocity reached as Apollo returns from the Moon. The command module splashed down six miles from the planned spot in the Pacific Ocean, 800 miles northwest of Hawaii, 8 hours, 37 minutes and 8 seconds after Saturn V had roared away from Pad A.

When the spacecraft was later intensively examined, engineers jubilantly reported that the heat protection afforded by the blunt ablation shield had withstood the test of more than 5,000 degrees heat load. The temperature inside the Apollo spacecraft, where one day three astronauts would ride, climbed only 10 degrees and never exceeded 70 degrees. Performance of the vehicle and its cargo had been letter perfect throughout the mission.

Congratulations poured into NASA Headquarters and the three manned space flight centers. President Johnson telephoned his commendations to the Marshall Center. Vice President Hubert H. Humphrey called Dr. Debus and extended his praise to Kennedy, Marshall and the Manned Spacecraft Centers. So did NASA Administrator Webb. By wire and letter, leading figures in science, technology and business added their praises.

Dr. Mueller dispatched his thanks to Dr. Debus, noting that "we have take a very large step forward — in my view, it is the most significant single milestone of the Apollo/Saturn program. Yet there are many that have still to be surmounted. It will take the unremitting efforts of every member of the Apollo team to bring to fruition the hopes and expectations of the people — landing Americans on the moon and returning them safely to earth within this decade."

X

Resuming Manned Flight

AN atmosphere of confident anticipation permeated the Kennedy Center as the New Year began. The unqualified success of Apollo 4 and the perfect operation of the first Saturn V launch vehicle supplied eloquent testimony to the technical competence, discipline and high state of morale of the launch organization. Before 1968 was to end, other launches would carry the space program to new levels of international attention and acclaim.

Even as echoes of the Apollo 4 triumph reverberated through the halls of Congress and in the press, preparations continued to move ahead smoothly at Complex 37 for the first orbital test of the lunar module — the buglike spacecraft in which two men eventually would land on the Moon. It would be flown on Apollo Saturn 204, the Saturn IB vehicle built by Chrysler, McDonnell Douglas, International Business Machines and North American Rockwell. Grumman supplied the lunar module.

Known as Apollo 5, this mission began the morning of January 22 when the Saturn rose majestically from its launch pedestal carrying the lunar module weighing 31,700 pounds. Within minutes, the spacecraft was inserted into Earth orbit as planned and then separated from the second, or S-IVB stage, of the carrier rocket.

From that point on, for the duration of the test, the module responded to commands, either those pre-programmed into its system, or to new instructions transmitted by radio links to the unmanned vehicle from the Mission Control Center in Houston. Both ascent and descent propulsion systems operated satisfactorily. The flight demonstrated that these systems could be throttled while operating, and that the engines could be started, stopped and restarted in space. No attempt was made to return the lunar module to Earth since it is not designed to withstand reentry heating but rather to function only in the lunar environment where the force of gravity is only ine-sixth that of Earth.

On February 6 the second Saturn V launch vehicle was carried from the Vehicle Assembly Building to Pad A of Complex 39 by the crawler transporter in preparation for the launch of Apollo 6. This would be another test of the vehicle and of the spacecraft's ability to withstand reentry heating at lunar return velocities.

While checkout and test operations proceeded, the White House announced a major change in top level NASA management. Dr. Thomas O. Paine was designated Deputy Administrator, succeeding Dr. Robert Seamans who had resigned in late 1967. Dr. Paine had managed the General Electric Center for Advanced Studies in Santa Barbara, California for five years. Immediately after his selection, Dr. Paine visited Kennedy's Western Test Range launch complex and was briefed on the operations conducted there by Henry Van Goey, the resident KSC manager.

Apollo 6 was launched precisely on schedule the morning of April 4, carrying a payload calculated to weigh 93,885 pounds into Earth orbit. The countdown had been uneventful. Both vehicle and spacecraft had responded satisfactorily to all of the checkout procedures and pre-launch tests. However, some anomalies occurred during the powered flight of Saturn V. One of the five engines of the S-II, hydrogen fueled second stage, shut down prematurely and three seconds later, a second engine ceased to function. To compensate for this loss of thrust, the third stage burned 29 seconds longer than planned. As a result, the Apollo spacecraft was inserted in orbit and the mission continued.

Later, another problem developed. The third or S-IVB stage failed to reignite as programmed and consequently did not boost Apollo to the desired altitude above Earth in order to simulate the lunar return conditions. After the Apollo spacecraft had been separated from the stage, by means of ground commands, it was maneuvered to the desired position in space by employing the Apollo propulsion system, then steered into reentry at greatly increased velocity almost that which would be encountered by a spacecraft returning from the Moon. The 10-hour flight terminated with the recovery of the spacecraft in the Pacific — Apollo stood up well under this severe test.

As the launch vehicle designers pored over the performance data accumulated during the powered flight of Saturn V, they determined that the shutdown of second stage engines occurred because of a wiring error. They also found that spark igniters linked to the second and third stage engines, which are identical, failed to operate properly. That explained the failure of the third stage to reignite in Earth orbit. They also learned — and all of this data was available because of the instrumented measurement program installed at the Kennedy Center — that

the 1,500,000-pound thrust engines of the first stage operated synchronously, causing unacceptable longitudinal oscillations. So the Government-industry vehicle team plunged into the task of finding solutions.

By brilliant detective work, the causes were pinpointed quickly and convincingly demonstrated in ground testing of similar systems. Marshall's engineers proved that by introducing helium into the propellant lines of the S-IC, or booster stage engines, the "pogo effect," as the press described the longitudinal oscillations, could be suppressed. Spark igniter lines of the second and third stages were strengthened. Procedural safeguards were supplemented to ensure against any mistakes in wiring. In late April, Lt. Gen. Samuel Phillips, the Apollo Program Manager, recommended that the next Saturn V mission, Apollo Saturn 503, should be manned — unless subsequent developments during assembly, checkout and test raised new and unexpected questions. Following this judgment, the S-II stage of AS 503 was demated, or removed, from the vehicle at KSC and returned to the Mississippi Test Facility, there to undergo additional "hot" firing in order to manrate it for the Apollo 8 mission.

While these developments occupied the attention of the launch team, the organization which successfully launched Apollo 5 in January had been busily at work on Launch Complex 34, preparing another Saturn IB rocket, Apollo Saturn 205, to launch the first manned Apollo spacecraft identified as Apollo 7.

The Apollo spacecraft team, Government and contractors, gathered in the Center's training auditorium May 31, 1968 for an unusual occasion. The command and service modules for the manned launch had arrived and were about to undergo rigorous processing and inspection. The prime Apollo 7 crew, Walter Schirra, veteran of both Mercury and Gemini missions; Walter Cunningham and Donn Eisele had entered the flight preparation stage of training. Schirra and Cunningham interrupted their schedule in order to talk to the men and women charged with the responsibility of making their spacecraft launch ready.

The two astronauts, looking trim and eager for this renewal of manned spaceflight, had witnessed the Memorial Day fixture at the Indianapolis Speedway. Schirra had this to say: "We had a rather intensive training schedule at Indianapolis. We were engaged in a low orbital, high velocity satellite program to observe whether jets were better than piston-slappers. The jets lost."

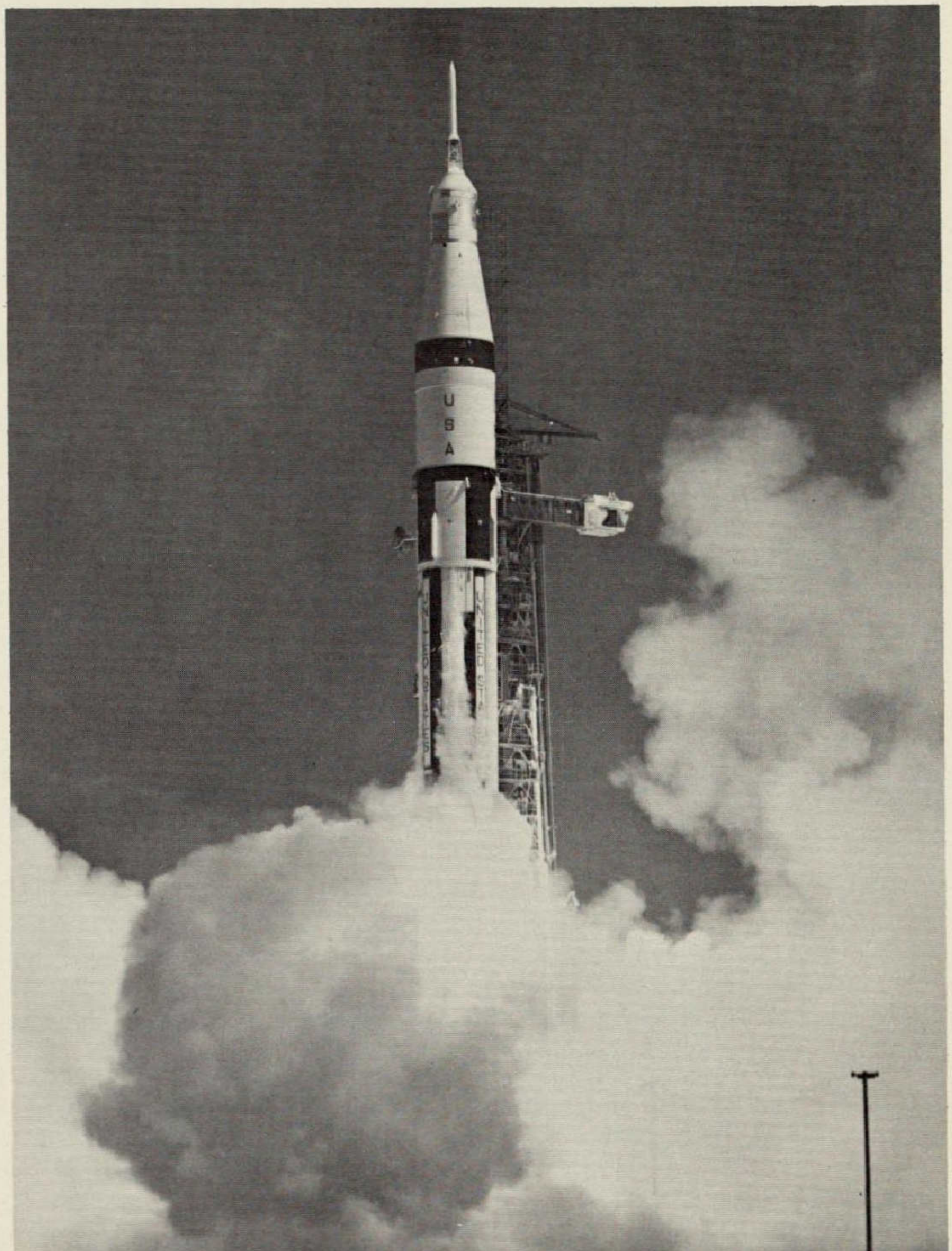
In more serious vein, Schirra told the group that "Your record stands without our saying anything. You've gotten off some beautiful flights. We're just going to foul it up a bit and put man in there and make it work better. That's our intent." Cunningham added: "We're

about ready to start testing the fruits of the manned spacecraft program again. I think the fruits are many. That's going to occur with liftoff sometime this Fall and that's where we want to have the proof of the pudding. We're trying to assure you that you'll have the best possible crew flying that spacecraft. We're asking you to deliver a spacecraft that's going to go the full 164 laps."

Stages of the IB vehicle had arrived in March and April. While the launch vehicle team conducted the normal checkout and test procedures at Complex 34, validating the two stages of the rocket and the instrument unit, the Apollo spacecraft underwent validation testing and inspection in the Manned Spacecraft Operations building, a painstaking process requiring countless hours of attention to minute details and components by highly skilled engineers and technicians. In late July the prime crew successfully completed the vital test of the spacecraft in an altitude chamber where it withstood the simulated environment of 200,000 feet above Earth's surface. The backup crew, Tom Stafford, John Young and Eugene Cernan, manned the craft for similar testing. For these gruelling tests, running nine hours or more, the crews were completely suited. They began operations in an atmosphere composed of 60/40 per cent oxygen and nitrogen, later changed to 100 per cent oxygen at 5 psi — the same environment that would subsequently be provided in Apollo during the countdown and launch.

In mid-August, the spacecraft was transferred to Complex 34 and mounted atop the Saturn launch vehicle. Paul Donnelly, the Launch Operations Manager, supervised the preparations with the help of Don Phillips, Test Supervisor; Norman Carlson, Launch Vehicle Test Conductor and Skip Chauvin, the Spacecraft Test Conductor. Daily, Schirra, Cunningham and Eisele rehearsed the mission in the Apollo training simulator, communicating directly with the flight controllers back in Houston.

Between September 11 and 16, the team carried out the countdown demonstration test in which both rocket and spacecraft were completely fueled and the countdown procedure followed exactly step by step, stopping short of igniting the eight 200,000 pound thrust engines of the first stage. This was followed by the flight readiness test, in which the astronauts participated, which continued four days. Involved in this phase were rehearsals of abort runs and mission simulations with the Mission Control Center, Houston. As one of the emergency egress modes, a slide wire was installed on the Complex 34 service tower at spacecraft level. Astronauts wore light harness straps with which they could hook on trolleys mounted on the wire, the pad crew being similarly equipped, and descend rapidly to the ground over a run of 1,250 feet if this should



Saturn IB vehicle lifts off Complex 34 as Apollo 7, the first three-man spaceship, began its eventful mission October 11, 1968.

become necessary. Schirra, Cunningham and Eisele rehearsed this procedure from a point about one-third up the overall height, then obligingly posed for newsmen's photographs.

The combined manned space flight organization convened to review the status of preparations on October 3 and pronounced crew, rocket and spacecraft ready. The days sped by then until October 11. More than 700 newsmen, 2,000 distinguished guests and millions of television viewers watched anxiously as the count proceeded. In the blockhouse, 250 members of the team monitored the fueling and other preparations while 50 more operated the automatic checkout equipment married to the Apollo spacecraft in the Manned Spacecraft Operations building.

At T minus 6 hours, 50 minutes, the 3,000-ton service structure rolled back in preparation for loading propellants which began at T minus 6 hours. The crew departed their quarters, cheered by employees and the press in nearby locations, and entered Apollo 7 at T minus 2 hours, 25 minutes. At T minus 40 minutes when the countdown entered the period of maximum hazard, the pad area was cleared, workers moved either into the control center or drove to fallback areas a mile away. A short hold occurred to permit the second stage engine to chill down, then the count resumed.

At T minus 2 minutes, 43 seconds the automatic prelaunch sequence began, proceeding without interruption to ignition of main stage engines at T minus 3 seconds. Apollo 7 rose from the pad at 2 minutes and 45 seconds after 11 a.m. Eastern Daylight Time. When the mission ended 10 days later, Lt. Gen. Samuel Phillips, Apollo Program Director, pronounced it "101 per cent perfect."

During their orbital flight, the crew achieved every mission objective. They maneuvered Apollo to simulate docking with the S-IVB stage as it slowly tumbled. They tested air-to-ground communications, ignited and re-ignited the Apollo rocket engine eight times, and verified that the functional systems of both service and command modules operated perfectly and responded when and as they must.

As a new and welcome innovation in U.S. manned spaceflight, the Apollo 7 crew employed a lightweight television camera designed to photograph activities within the spacecraft, and the breathtaking view from the windows for the delighted edification of the television audience on Earth. The public could witness for the first time the effects of weightlessness as Walter Cunningham floated around the cabin and thus helped to enhance the understanding of the zero gravity phenomenon. These entertaining exposures, spiced with spontaneous humor, opened up a new dimension in NASA's efforts to make space flight understandable. In all, it was a flawless performance that restored con-

fidence in the U.S. manned space team — the first flight since Gemini's closeout in November 1966, and the first since the tragic fire of January 1967. Beyond all question, it proved that while that tragedy was costly in the extreme, hard lessons had been learned, corrections had been made, and the lessons had not been forgotten.

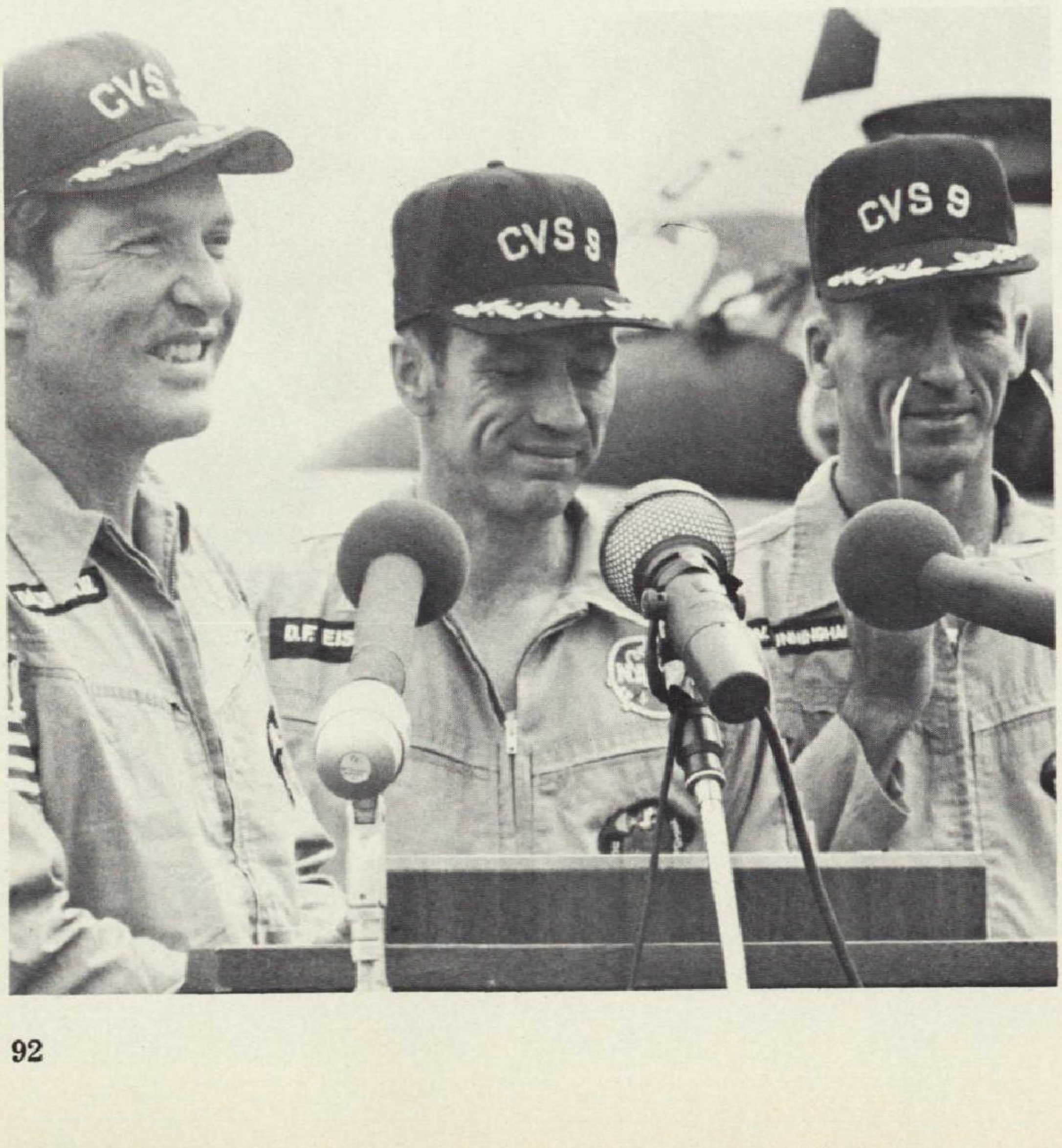
President Johnson thanked the astronauts personally during a post-flight ceremony at his Texas ranch where they received NASA medals from Dr. Thomas O. Paine, then Acting Administrator. Subsequently, other honors were paid to the launch team, the rocket developers, and the flight control team of the Manned Spacecraft Center. Dr. Paine made the presentations to KSC recipients, including Rocco Petrone, Donald Buchanan, Isom Rigell, and Dr. Debus who accepted a group award on behalf of the Center organization in November during a visit of Mrs. Lyndon B. Johnson. At the same ceremony, a special award was

Back from space, Apollo 7 crew welcomed at Cape's landing strip by (left to right) Maj. Gen. David Jones, Dr. Kurt Debus, Rocco Petrone, Ray Clark and Rear Adm. R. O. Middleton of KSC.

conferred upon Rear Admiral Middleton, the Apollo Program Manager, and a large number of KSC personnel for their work in activating Complex 39. A NASA medal was presented to Albert F. Siepert, the Deputy Director for Center Management, in recognition of his outstanding work for the agency and the Center.

When the Apollo 7 astronauts returned from splashdown in the Atlantic on October 22, they spent four days in debriefings at Kennedy before moving on to Houston. On their touchdown at the Cape Kennedy Skid Strip, they received an enthusiastic welcome from assembled launch team members, 2,500 in all, in the traditional greeting. Captain Schirra responded by thanking the KSC group for their vital contribution to his successful mission.

Apollo 7 astronauts expressed their appreciation to the KSC launch team. Left to right: Walter Schirra, Donn Eisele and Walter Cunningham.



XI

Men To The Moon

AN unusual guest arrived at the Space Center in late June, 1968. He was Alexandru Birladeanu, the Deputy Prime Minister of Romania and the first official visitor from an Iron Curtain country to the Spaceport. The point was not lost on the Minister who listened attentively to a briefing concerning the manned lunar program and then remarked:

"I want to talk to you as a man and not a politician. It seems we are the first Soviet delegation visiting this place. But mankind's interests are the same regardless of which camp you are in. The economic and technological might of the United States played an important role in reaching these space accomplishments. And I'm sure that the talents and qualities of your people played a most important role. This race to the Moon is a result of the competition between the two super powers, but taking into consideration the interests of all mankind, it is not as important who will be first on the Moon as it is important that somebody should get to the Moon. Not many of us present today will have a chance to enjoy the benefits of that achievement, but it is certain that our children will benefit. I wish you every success from my heart."

Later, the Minister asked how the United States space program compared with that of the Soviet Union. The briefer explained that would be difficult to analyze since the Soviets do not announce what they plan and are quite selective in what they disclose. He smiled and replied, "They don't tell us either."

As subsequent events demonstrated, the United States conducts its space exploration program without regard to possible competition. NASA moved promptly to exploit the full potential of the massive Saturn V system and get on with the business of reaching the Moon.

While preparations for the Apollo 7 manned launch continued a few miles to the south at Complex 34, the launch organization checked

out, assembled and tested AS-503, the third Saturn V vehicle. The huge booster arrived December 27, 1967. Three days later it was erected on the mobile launcher in the Vehicle Assembly Building. This was the stage which lifted Apollo 8 from Earth December 21, 1968.

The second stage joined the first January 31, 1968. The third stage and the instrument unit topped off the launch vehicle next day. By early February the configuration had reached full height with the addition of a lunar module test article and a boilerplate command and service module combination which would never fly, but which permitted checkout to proceed while awaiting the flight spacecraft. AS-503 would be launched in a third, unmanned demonstration of the Saturn V vehicle in the event the problems which developed during Apollo 6 were not completely resolved.

But by April 27, the Apollo 6 anomalies had been diagnosed and

Romania's Deputy Prime Minister, holding framed photograph, expresses thanks to Center Director Dr. Kurt H. Debus for the memento of his visit.

solutions were under active investigation and test. The decision was then made to prepare AS-503 to carry a crew — Astronauts James A. McDivitt, David R. Scott and Russell L. Schweikart. Accordingly, the upper stages were taken down. The second, 1,000,000-pound thrust hydrogen fueled stage was shipped to Mississippi Test Facility to undergo hot firing tests for manrating.

Having stood up well to this test by fire, the stage came back to the Kennedy Center June 27, and was later returned to the mobile launcher atop the booster stage. NASA planned, at the time, to install a lunar module with the Apollo command and service modules, placing them in Earth orbit. There the crew would rendezvous and dock the modules. Two of the astronauts would transfer into the lunar ship, separate it from Apollo, and operate it independently in the weightless environment for the first time.

As KSC spacecraft engineers subjected the lunar module to rigorous testing and inspection, however, it became increasingly evident that this first manned flight item required extensive rework modifications. In fact, there was no chance of meeting the anticipated 1968 launching date. Confronted with this problem, NASA examined alternate missions which would not involve the lunar module.

On August 19, NASA made an historic announcement. The mission of Apollo 8 was changed to involve lunar orbit. The crew previously designated for Apollo 9, comprised of Frank Borman, James Lovell, Jr., and William Anders, would take over the mission since they had been preparing for such a flight, while Astronauts McDivitt, Scott and Schweikart would continue training for the first use of the lunar module in Earth orbit for Apollo 9. Spacecraft Commander Borman and Command Module Pilot Lovell were veterans of Gemini experience. The two men had piloted Gemini VII for 330 hours and 35 minutes. Lovell next teamed with Edwin E. Aldrin in Gemini XII, last of the two-man program, for 94 hours and 34 minutes. Anders was assigned the position of Lunar Module Pilot.

With the decision to man AS-503, worked stepped up to a three-shift, six-day week at Kennedy. Rocco A. Petrone, then Director of Launch Operations, assigned Paul Donnelly as Launch Operations Manager. William Schick became test supervisor with Ray Roberts serving as the launch vehicle test conductor and Richard Proffitt, spacecraft test conductor. Raymond L. Clark, Director of Technical Support, chose Gary Richards and Roy Tharpe as test support controllers. There were two main theaters of KSC pre-launch work, the Vehicle Assembly Building where the Saturn V stood on its launcher, and Manned Spacecraft Operations Building where the Apollo command and service modules underwent

checkout and test in stands and the altitude chamber.

Launch vehicle engineers of Boeing, North American Rockwell, McDonnell Douglas, International Business Machines, Rocketdyne and other contractors teamed with supporting firms in the VAB and on Pad A, Bendix, Federal Electric Co., Trans World Airlines, Catalytic-Dow and Ling Temco Vought, to prepare the Saturn V rocket. Equally skillful engineers representing North American Rockwell, General Electric, AC Electronics, Aerojet General and Massachusetts Institute of Technology worked with the same supporting contractors in the spacecraft building's high bay area.

Once mated, the Apollo modules successfully passed major testing in the altitude chamber September 20 and 22. The prime crew took part in one test while the back up crew, Astronauts Neal Armstrong, Edwin Aldrin and Fred Haise participated in the other test. On October 7, engineers transferred the Apollo to the Vehicle Assembly Building and installed the spacecraft on the launch vehicle. Next day the rocket-powered launch escape system topped off the assembly. As the sun rose over Pad A October 9, the Apollo Saturn configuration and its mobile launcher slowly emerged from the VAB, carried by the crawler, while Astronauts Borman, Lovell and Anders watched with smiles of anticipation. Apollo 8 stood on the launch pad that evening while a few miles to the south, the Apollo 7 team counted down the Saturn IB vehicle launched two days later.

In mid-November the crew participated in a flight readiness test which included abort and mission simulations, breaking off the rehearsal at noon November 19 to join a distinguished visitor who was lunching with Dr. Debus. He was Vice President Hubert H. Humphrey, chairman of the National Aeronautics and Space Council, who paid his first visit to the Center after the 1968 Presidential election. Then and there the Vice President declared his intention to witness the Apollo 8 launch. Unfortunately, influenza intervened when the time arrived and he was represented instead by his son.

Next came the critically important countdown demonstration test when both spacecraft and launch vehicle were fully fueled, as if for launch, without the astronauts aboard. They were otherwise occupied, as they had been for months, in daily sessions in the Apollo simulators, rehearsing with painstaking precision the entire mission.

As anticipated, problems cropped up during the prelaunch checks. An intermittent computer anomaly caused some concern but was resolved by joint efforts of Marshall Space Flight Center, KSC and IBM engineers. A redline value showed in the booster engine environmental control system during the countdown demonstration.

The instrumentation system was re-calibrated. MSFC engineers re-checked the system, concluding that the redline value was higher than necessary. So the countdown proceeded. Subsequently, an engine fuel leak demanded attention of Rocketdyne and Marshall experts. Through simulations, they were able to demonstrate that the leak would not occur under normal operating conditions.

The matter of disposing of the third stage of Saturn V had to be settled. After the 200,000-pound thrust rocket propelled Apollo into lunar trajectory at a velocity of 24,302 miles per hour, there had to be positive assurance that it would not crash into the Moon and that it would not bang into the Apollo spacecraft. The flight plan called for the space-

Leaving Manned Spacecraft Operations Building enroute to the Apollo 8 spacecraft, astronauts Borman, Lovell and Anders.

craft to separate from the stage once escape velocity was achieved. Both objects would be traveling at the same velocity in the same direction. The solution was to aim the spent stage so that it would "hook" behind the Moon and employ lunar gravity to accelerate the S-IVB rocket into orbit around the Sun, passing within 780 miles of the lunar surface.

The Kennedy Center prepared for a mass invasion. From requests funneled into NASA, it was apparent that more than 1,000 press, television, radio, and other correspondents would witness the launch. They began arriving five days before the event. Among them, for the first time, was a British Broadcasting Corp. crew prepared to cover the launch in real time and beam the picture and sound to Europe by satellite, also launched earlier from the Kennedy Space Center. Correspondents arrived from the Far East and Europe; in all, 131 media from 23 countries, swelling the total to 1,300, or the largest turnout for any NASA launch.

Agency headquarters and the manned flight centers invited well over 2,000 distinguished guests for the occasion. Among them were Supreme Court Justices, the Washington Diplomatic Corps representing 69 nations, Governor Kirk of Florida, Governor-elect Preston Smith of Texas, scientists, businessmen, clergy, doctors, lawyers and educators — again, the largest collection of dignitaries ever to view a NASA launch.

From the Congress came U.S. Senators Frank E. Moss of Utah, Edward Kennedy of Massachusetts, and Ralph W. Yarborough of Texas; Representatives John Culver of Iowa; Olin E. Teague, J. J. Pickle, Robert C. Eckhart, Bob Casey, Graham Purcell, Elizio Delagarza, Abraham Kazan and Omar Burleson of Texas; Emilio Q. Daddario of Connecticut, Robert O. Tierman of Rhode Island, Carl Albert and James Smith of Oklahoma, James G. Fulton and Joseph Vigorito of Pennsylvania, Fletcher Thompson and Benjamin Blackburn of Georgia, James Harvey of Michigan, Charles Wiggins, Edward Roybal, Lionel Vandeerlin, Burt Talcott, and George P. Miller of California; David Pryor of Arkansas, William Widnall of New Jersey, Ken Heckler of West Virginia, Samuel N. Friedel of Maryland, and Congressman-elect Lou Frey of Florida.

The launch window for Saturday, December 21, opened at 7:51 A.M. Eastern Standard Time. Since the rocket would be fired as the Earth revolved, and since the Moon was also in motion, that was the ideal moment to begin the mission in order to intercept the Moon at the right time in the right place. While much more complex in actuality, the problem is not dissimilar to that of the hunter shooting at a moving target.

Since the countdown had been relatively uneventful, thanks to those weeks and months of painstaking preparation which led up to the launch, attention turned to the weather. Conditions on December 20

were far from ideal at the launch site. It was foggy in early morning, there was little or no wind, and the chief forecaster, Ernest Amman of the local office of the Environmental Science Services Administration, inclined to expect similar conditions next day. He held out a faint prospect, however, that a weak front to the north might develop sufficient pressure to clear the air at launch time.

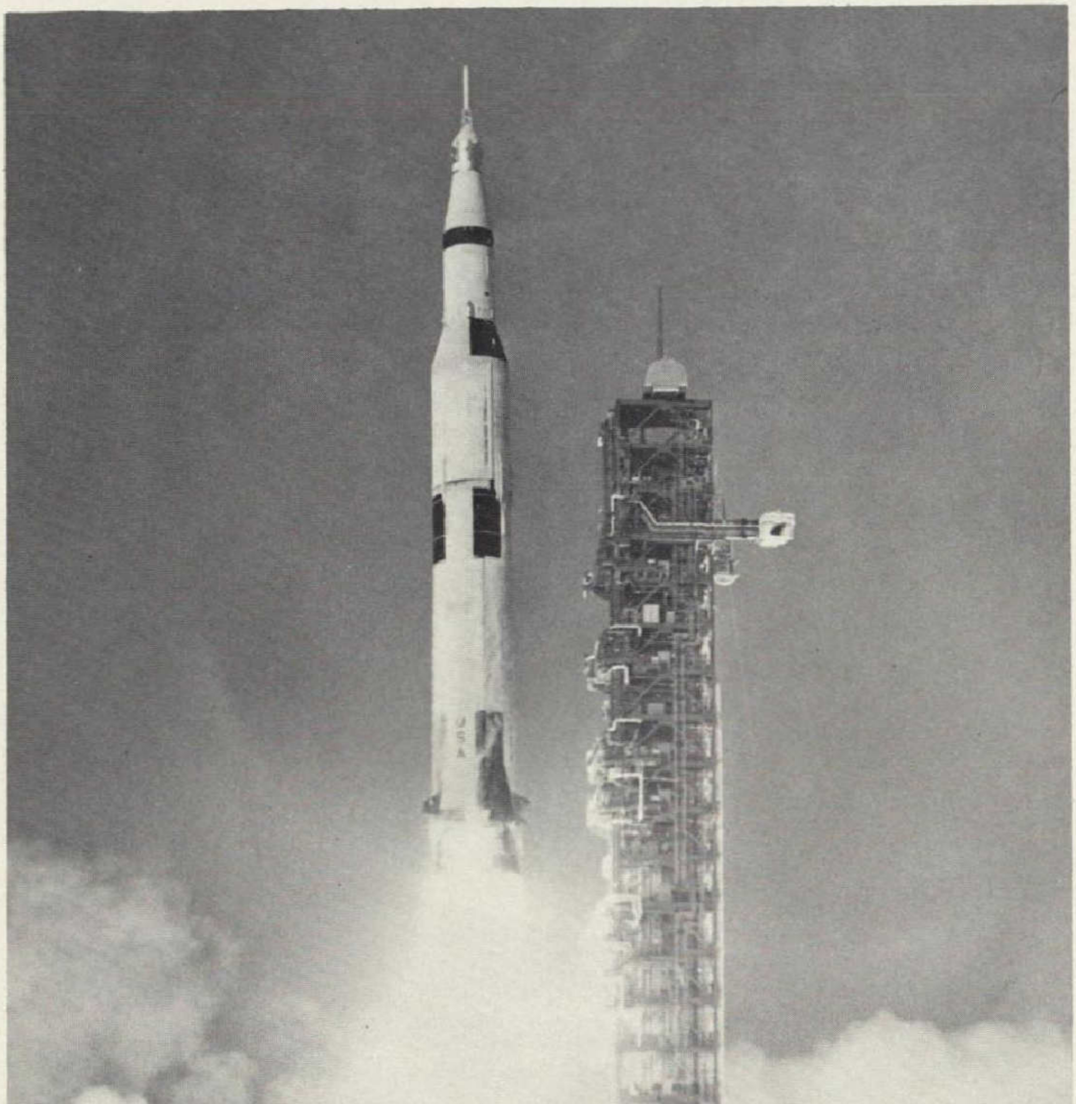
In these circumstances, KSC officials decided to proceed with fueling and continue the countdown to a point within minutes of ignition, then to sit if necessary with a fully prepared vehicle until the ground weather conditions permitted launch. As it turned out, the decision was eminently sound. The next morning dawned bright and clear although a 40-degree temperature before sunrise made it somewhat uncomfortable for the 250,000 onlookers who streamed into Brevard County, parking along the highways and causeways at vantage points to see the liftoff.

Donald (Deke) Slayton, Director of Flight Crew Operations for the Manned Spacecraft Center, roused the astronauts at an early hour. They enjoyed a hearty breakfast of filet mignon, eggs, orange juice, cake and coffee. They suited up, then traveled in a special van to the launch pad eight miles away, rode the elevator up the launcher tower to spacecraft level, crossed the access arm and entered the Apollo spacecraft with the help of the closeout crew.

Exactly on time, at 7:51 A.M., the five powerful engines of the first stage roared into flame under the 363-foot tall vehicle. Eight seconds later, the computer released the holddown arms and the giant rocket began to rise from the launcher deck.

At 125.9 seconds later, the center engine in the cluster of five shut down precisely as planned. The four outboard engines continued to build up thrust until 153.8 seconds, just 2.4 seconds longer than predicted. Engineers attributed this event to a higher than predicted fuel density of minor interest. The second stage engines began operating 155.2 seconds after liftoff and continued for six minutes and nine seconds as planned. By that time, the configuration was well down the Eastern Test Range and traveling about 15,000 miles per hour.

The third, or S-IVB stage, started up at 525 seconds and carried Apollo into a parking orbit around the Earth at a velocity of 17,000 miles per hour. The spacecraft and stage coasted in orbit while ground controllers and the astronauts checked out the spacecraft systems. The mission had been planned with three commit points: the launch itself, the parking orbit around Earth, and the translunar coast preceding the point at which the Apollo would be slowed down to enter orbit about the Moon. Had any problem been detected at these points, the plan was to shift to alternate missions, thus providing maximum crew safety as well as enhancing the scientific and engineering dividends from the



Apollo 8, atop this Saturn V launch vehicle, roars off Pad A at Complex 39 the morning of December 21, 1968 as the historic journey to the Moon began.

flight. With the decision to burn the 200,000-thrust engine of the third stage again for translunar injection, it was ignited 2 hours, 50 minutes and 36.4 seconds after liftoff. The engine functioned perfectly for 5 minutes, 18.6 seconds and increased spacecraft velocity to 24,400 miles per hour, or the speed necessary to break free from Earth's gravitational field and reach the Moon.

Shortly after this second burn of the third stage was completed, the stage and ballast that took the place of the lunar module were jettisoned. The crew then maneuvered Apollo into a slight change in course to keep it away from the spent rocket stage. After the flight, Marshall Space Flight Center engineers reported the instrument unit which guided and controlled Saturn V functioned with extreme accuracy. It not only steered the huge vehicle into precise Earth orbit but the guidance on the translunar trajectory was so accurate that the astronauts required only one, small mid-course maneuver. Actual flight azimuth was 72.124 degrees as planned. The Earth orbital period was 88.19 minutes, with an apogee of 115.1 statute miles, or one-tenth mile higher than expected, and perigee of 114.3 statute miles, or seven-tenths of a mile lower than predicted.

Dr. Wernher von Braun, Marshall's director, said he was completely satisfied with the superb performance of Saturn V on which his Center and its contractors had worked six years. Vehicle and spacecraft obviously fared well in the care of the KSC launch organization.

At 5 A.M. Eastern Standard Time December 24, Apollo 8 had reached the third and last commit point. Commander Borman turned on the engine of the service module to slow Apollo in a retrofire maneuver and thus entered lunar orbit which varied between 60.4 and 168 miles above the Moon's surface. At 9:26 A.M., Borman again fired the service engine to circularize the orbit at 60.5 and 60.9 nautical miles. Apollo circled the Moon 10 times over a 20-hour period. That evening, shortly before 10 P.M., as people on Earth watched in fascination, the crew operated the television camera in a panoramic sweep of the lunar surface. This and other live telecasts from Apollo 8 were picked up by NASA's 85-foot diameter dish antennas at Goldstone, Calif., and Madrid, Spain which relayed the signals to stations in Europe as well as the United States and Far East. People everywhere saw the full disk of Earth from a distance of 114,000 miles on the outward leg of the flight, and later from 195,000 miles. They saw the Moon's surface from a distance of 60 miles and "earthrise" as the Earth appeared over the lunar horizon.

On that Christmas Eve telecast, this memorable commentary came from the spacecraft:

"I hope all of you back on Earth can see what we mean when we

say that this is a very foreboding horizon, a rather dark and unappetizing looking place. We are going over one of our future landing sites called the Sea of Tranquility. Now you can see the long shadows of the lunar sunrise. For all the people back on Earth, the crew of Apollo 8 has a message that we would like to send to you."

Astronaut Anders then began to read from the Book of Genesis:

Pock-marked lunar surface was clearly visible against the void of outer space as Apollo 8 sped round the Moon 10 times at a height of about 60 miles.

"In the beginning, God created the Heaven and the Earth. And the Earth was without form and void and darkness was upon the face of the deep. And the spirit of God moved upon the face of the waters and God said, let there be light. And there was light. And God saw the light and that it was good, and God divided the light from the darkness."

Astronaut Lovell continued, "And God called the light day, and the darkness he called night. And the evening and the morning were the first day. And God said, let there be a firmament in the midst of the waters. And let it divide the waters from the waters. And God made the firmament, and divided the waters which were above the firmament. And it was so. And God called the firmament Heaven. And evening and morning were the second day."

Astronaut Borman read on, "And God said let the waters under the Heavens be gathered together in one place. And the dry land appear. And it was so. And God called the dry land Earth. And the gathering together of the waters called He seas. And God saw that it was good. And from the crew of Apollo 8, we pause with good night, good luck, a Merry Christmas and God bless all of you — all of you on the good Earth."

None who heard would ever forget.

Next morning, as churches throughout the Christian world observed Christmas and at almost the exact hour when those in the Eastern part of the nation were concluding midnight services, Borman once more called upon the Apollo engine — this time for the sharp increase in velocity essential to break free of lunar gravity and begin the return trip to Earth. It was a critical event and it occurred exactly on schedule at 1:10.17 A.M. Eastern Standard Time. The engine fired 209 seconds.

To anxious listeners, awaiting confirmation of the maneuver, seconds crawled by until at 1:20 A.M., the Mission Control Center announced that telemetry confirmed the burn. Then came this memorable voice from the Moon: "Please be informed there is a Santa Claus." Next, the spacecraft reported: "It burned on time. Burn time 2 minutes, 23 seconds 7/10 plus BGX. Attitude nominal, residuals minus 5/10, BGX plus 4/10 minus 5/10 BGX plus 4/10 BGY plus 0 VGC delta VC minus 26.4."

Apollo 8 was on course, on time, at the right speed.

Late in the afternoon of December 25, a slight midcourse correction was achieved, so accurate that a planned second correction was not required. Once again, Earth's peoples saw their globe as the astronauts viewed it, growing steadily larger as Apollo came closer. The return journey was nine hours shorter than the outgoing trip thanks to the longer burn of the service module engine as they left the moon.

Preparing for reentry into Earth's atmosphere, the command and service modules were separated at 10:22 P.M. December 27. The spacecraft was turned blunt end forward, presenting the heat shield to the fiery temperatures of 5,000 degrees Fahrenheit generated by the high speed passage through the atmosphere. Apollo's arcing course had a roller coaster pattern due to the aerodynamic properties of the spacecraft. At 180,000 feet, its lift bounced the spacecraft back to 210,000 feet where it resumed the downward course. Drogue parachutes deployed at 34,000 feet, followed by the three main parachutes at 10,000 feet. Apollo splashed into the Pacific Ocean, in darkness, at a rate of 17 miles per hour, 147 hours and 11 seconds after liftoff from the Kennedy Space Center and within 5,100 yards of the USS Yorktown, the recovery carrier. The crew remained in the spacecraft until daylight and then rode baskets into the helicopter which flew them to the Yorktown's deck.

During the early phase of flight, the health of the crew caused some concern. Borman was twice nauseated and had an attack of diarrhea while Lovell experienced something akin to motion sickness. Their physician prescribed pills carried in the medicine kit and both recovered quickly.

Following days of debriefings, during which each member of the crew recalled every possible detail of the mission, the astronauts were flown to Washington January 9. President Johnson greeted them at the White House where NASA Distinguished Service Medals were presented. Then they were honored by a joint session of the Congress where their families were seated in the galleries to observe the occasion. Each astronaut in turn expressed his thanks for the tribute. Commander Borman, speaking for the crew, recognized the contributions of scientists and engineers who made the flight possible. He specifically mentioned the American workman, in these terms:

"He transformed the formulas, the equations, the thoughts into hardware, that to us was a living, breathing, magnificent piece of machinery. To the American workmen, we owe a special debt of gratitude."

Continuing, Borman said: "We stood on the shoulders of giants. Because how can anyone think of Apollo 8 without thinking of Galileo, Copernicus, Kepler, Tsiolkovsky, Oberth, Goddard, Kennedy, Grissom, White, Chaffee or Komarov. If Apollo 8 was a triumph, it was a triumph of all mankind and we acknowledge it as being such.

". . . The progress of exploration will be determined, not by the scientists, technologists or engineers, but rather by the people on this Earth. Exploration is the essence of the human spirit and to pause,

falter or turn our back on the quest for knowledge is to perish. I hope that we never forget that. As we unfold the secrets of the Universe, you will look to the scientists and engineers, but for the future of this great country and this good Earth, we will look to you."

A ticker tape parade in New York, another in Houston, another in Chicago, a visit to the United Nations, dinners, attendance at the Super Bowl Game in Miami where the astronauts led the salute to the flag followed in quick succession. On January 13, at the Manned Spacecraft Center, NASA conducted an Apollo 8 awards ceremony at which 100 members of the Government-industry team were honored. Dr. Debus

The Apollo 8 crew brought back this memorable photograph of Earth as seen while their space ship orbited the Moon 240,000 miles away. Moon's surface visible in lower part of picture.

and Mr. Petrone received Distinguished Service Medals while ten other KSC officials received the Exceptional Service Award for their individual effort as well as that of the people they supervise. They included G. Merritt Preston, Raymond L. Clark, John J. Williams, Dr. Hans Gruene, Karl Sendler, Robert Gorman, Paul Donnelly, George Page, Rear Admiral Roderick Middleton and Ed Mathews. Similar awards were presented to Dr. van Braun and Marshall Space Flight Center officials, to Dr. Gilruth and Manned Spacecraft Center key personnel, to members of NASA's Office of Manned Space Flight, to the Department of Defense officers supporting the mission, and to key Apollo contractors.

APOLLO 8 ACHIEVEMENTS

This was the first time man had been under the dominance of the gravity of a body other than Earth.

The first time man traveled as far as 233,000 miles from Earth.

The first time man has navigated in cislunar space.

The first time man has been completely out of touch with his home planet, which was the period during lunar orbit when the spacecraft circled the back side of the Moon.

The first time man has traveled in excess of 24,000 miles per hour and re-entered Earth's atmosphere at speeds of nearly 25,000 miles per hour.

The first time man has been above the protective sheath of Earth's magnetic field.

The first time man has had a close-up view of the Moon with his own eyes, observed the dark side of the Moon (an area twice the size of the United States), photographed the Moon and brought the films back to Earth.

The first live television transmissions showing the full Earth disk.

The first launch of Saturn V with an Apollo crew.

All primary Apollo 8 missions were accomplished in full as well as every test objective, including five not originally planned.

All launch vehicle systems and all spacecraft systems functioned well. There were no major problems.

XII

Proving The Spacecraft

WHILE acclaim inspired by Apollo 8 showered down on the space program, NASA's manned space flight managers recognized the compelling need for two major tests before they committed an astronaut crew to attempt the lunar touchdown. The lunar module, which was designed to operate only in space and never to reenter the Earth's atmosphere, had flown once in the Apollo 5 unmanned mission aboard Saturn IB. But the spacecraft had never operated in the Moon's environment with the Apollo command and service modules. Apollo 9 would therefore subject the lunar module to strenuous testing in Earth orbit.

At the Kennedy Space Center, Government and contractor launch and support crews labored steadily to maintain the accelerated schedule of launching Apollos on two months' centers. For the spacecraft checkout teams, this meant a six-day week with the main effort carried by the day shift, somewhat fewer tasks by the afternoon shift, and cleanup or power down tasks assigned to the third shift. Launch vehicle crews operated on a five-day week, essentially the same dispersion of tasks across three shifts, and employed the sixth day to complete serial testing.

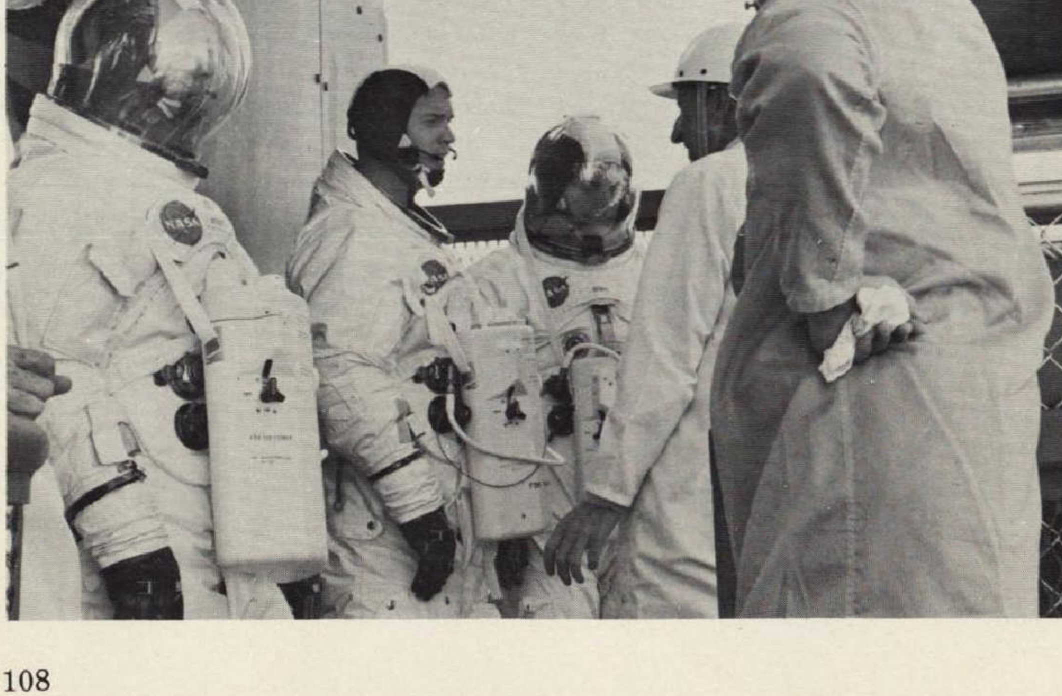
Grumman had delivered the Apollo 9 lunar module to KSC in June, 1968 when launch preparations began. Command and service modules arrived in early October coincident with delivery of the first stage of Saturn V by barge. The stage was erected on Mobile Launcher 2 in Bay 3 of the Vehicle Assembly Building. Second and third stages and the instrument unit were stacked atop the booster by October 7. Having completed testing and assembly of the spacecraft, engineers transferred the modules from the Manned Spacecraft Operations Building December 3 and they were carefully hoisted into place atop the launch vehicle.

Combined systems testing continued during the remainder of the month, even while Apollo 8 was circumnavigating the Moon. Support

crews operating the massive crawler moved the assembled Apollo 9 configuration to Pad A January 3, 1969 in preparation for the announced launch date of February 28th. Some problems were unearthed in the painstaking checkout process, as usually happens. For example, North American Rockwell corrected anomalies detected in the digital ranging generator of the Apollo spacecraft. Grumman fixed a water glycol leak observed between ascent and descent stages of the lunar module. A fuel pump was replaced. The flight readiness test, which exercises electrical systems, terminated successfully January 22d. Propellant loading of the Apollo spacecraft was completed the first week of February. Then the flight readiness review, a full-scale, detailed accounting for all organizations involved in the mission from launch through recovery, was conducted February 6th.

Rocco Petrone, the launch director, marshalled his forces for the countdown demonstration test that began February 12th. Jim Harrington, test supervisor, was assisted by Jack Baltar, test conductor for Saturn V; Skip Chauvin, test conductor for the Apollo and Fritz Widick, test conductor for the lunar module. Support Director Ray Clark desig-

Technicians brief Apollo 9 astronauts James A. McDivitt, Russell L. Schweickart and David R. Scott on emergency egress procedures at Complex 39A.

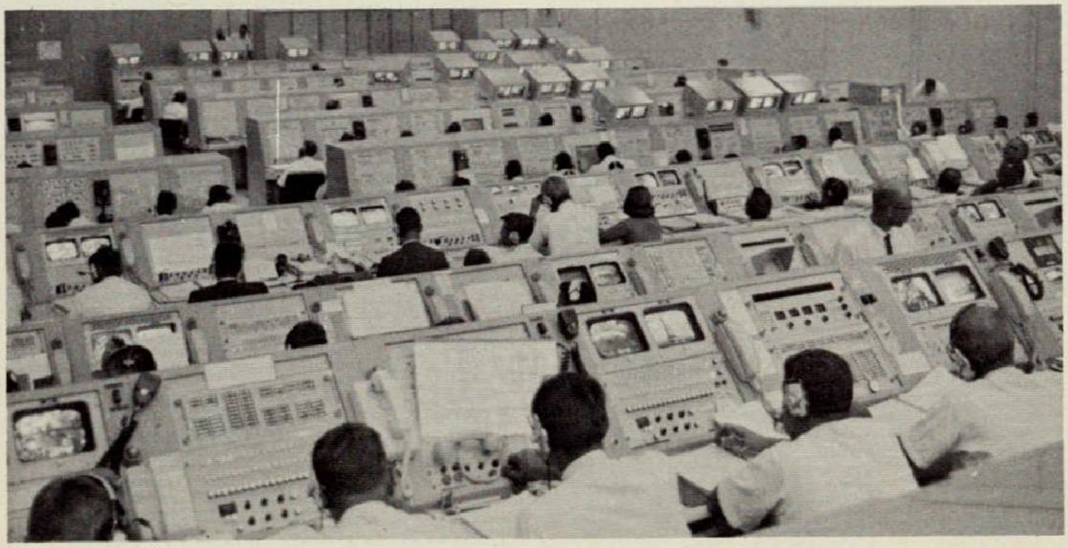


nated Jim Devlin as support controller. During the six-day test the vehicle tanks holding liquid hydrogen and, in the first stage, RP-1 or jet fuel, were loaded and the rehearsal carried down to the final minutes when the countdown procedure becomes automatic. The "wet" test concluded February 18th. Next day, after the vehicle tanks had been emptied of propellants, a "dry" test was conducted with the astronaut crew, Commander James A. McDivitt, Command Module Pilot David R. Scott and Lunar Module Pilot Russell L. Schweickart, ensconced in the spacecraft and taking active part.

Once these critical tests were over, launch vehicle and spacecraft were pronounced ready. Then the waiting period commenced that would end with the opening of the lunar window February 28th. The countdown began on time February 22d — once they enter this phase, there is no holiday for the launch crews — and proceeded smoothly until T—1 day when Apollo program officials prepared to brief the 1,000 press on hand for the event. However, shortly before that encounter took place in the Training Auditorium, the astronauts' chief physician, Dr. Charles Berry, advised that the crew had contracted a mild virus infection and should not fly. He recommended postponing the launch. As a result, the terminal countdown began at T—28 hours March 1st and concluded with another liftoff exactly on time at 11 A.M. March 3d.

Lt. Gen. Samuel Phillips, the program director, described the Apollo 9 mission as "the toughest we have tackled to date." Before returning to Earth 10 days later, the astronauts would accomplish these tasks:

Monitoring the countdown for the launch of Apollo 9 in the Launch Control Center.



—conduct engineering evaluation of the lunar module

—prove out joint operations techniques of both lunar and command/service modules

—test the portable life support system which astronauts employ on the Moon's surface

—turn Apollo around after injection into Earth orbit while traveling 17,500 miles per hour and guide it to a secure docking with the lunar module, then extract the latter from the Saturn V third stage to which it is attached

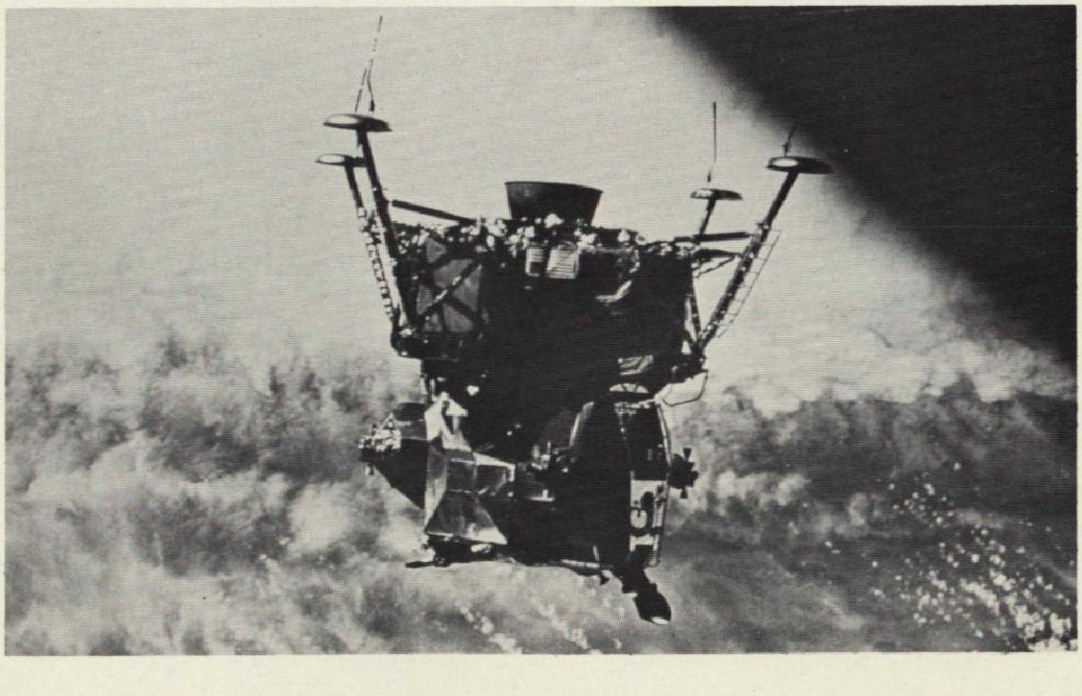
—fire the Apollo service propulsion system five times while the spacecraft were linked in orbit to evaluate the guidance system

—wring out all lunar module systems during docked and undocked maneuvers — in short, fly the module independently of the Apollo command ship

—perform some useful tasks outside the lunar module, a job for Astronaut Schweickart, who was making his first space flight

The crew dubbed the command ship "Gumdrop" and the lunar module became "Spider." Once again, live television transmissions from Apollo highlighted the 10-day flight for Earth observers. The backup crew for the mission, Charles Conrad, Richard F. Gordon and Alan L. Bean, would be heard from again — they would later fly Apollo 12.

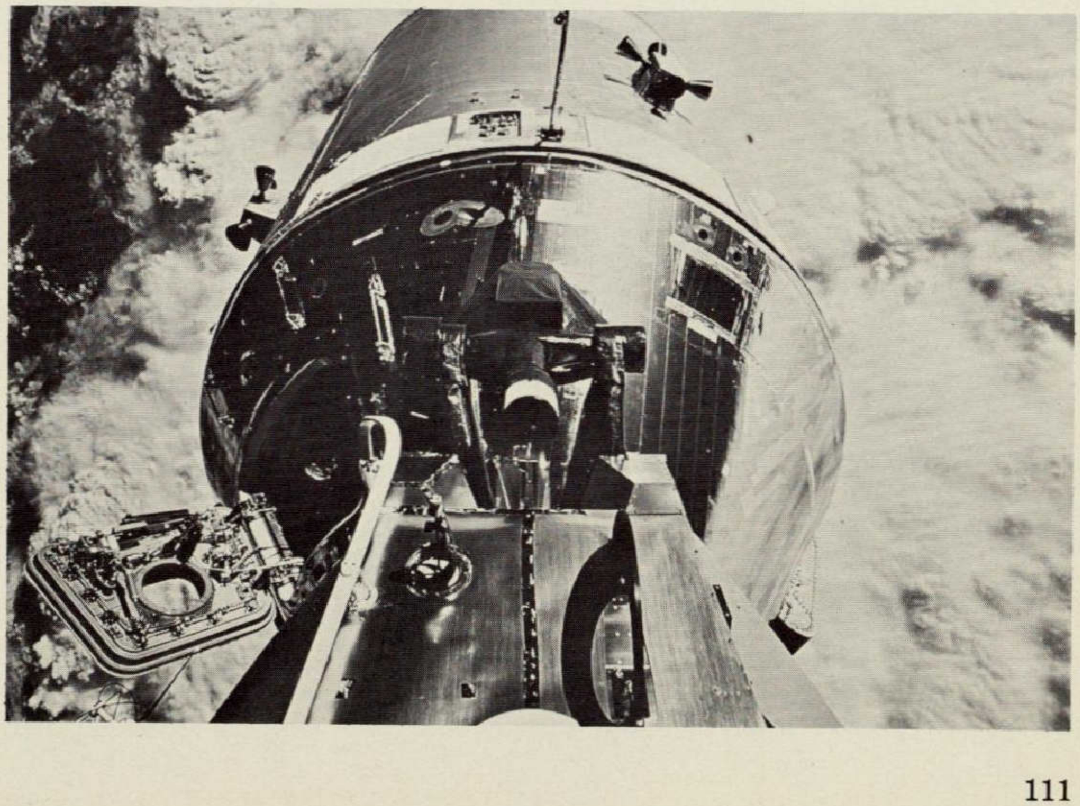
Spider, piloted by astronauts James McDivitt and Russell Schweickart, in its landing configuration following separation from Gumdrop. The spacecraft is flying upside down. Earth is visible in the background.



Three hours after launch Gumdrop pulled away from the S-IVB stage, turned around and docked with Spider. Explosive bolts fired and compressed springs pushed Spider free of the stage. Docked head-to-head, the spacecraft orbited Earth while Scott fired the Apollo 9 main engine several times to test it and to observe behavior of the joined modules under propulsion. Three days out, McDivitt and Schweickart crawled through the tunnel and entered Spider. They checked the lunar module electrical systems and computer, extended the legs which some day would be employed to contact the Moon, and fired the descent engine.

During the fifth day, McDivitt and Schweickart pulled away from Gumdrop and rotated Spider so that Scott could observe the lunar module. Then they fired the lunar module engine to move three miles from the command ship in an orbit equidistant from Earth but nearly parallel to that being flown by Gumdrop. In event of a problem, they would be close enough twice during each orbit to permit Scott to rescue his crewmates by completing a docking maneuver. For nearly six hours while 135 miles above Earth, and up to 111 miles from the Apollo, McDivitt and Schweickart put Spider through its paces, simulating descent from lunar orbit to the Moon and launch of the ascent stage from the Moon, and then flew back to rendezvous with Scott.

Photograph of docked Spider and Gumdrop by astronaut David Scott during Apollo 9 extravehicular activity.



Before that event, Schweickart crawled out of Spider's hatch carrying on his back the 90-pound life support system that supplies air to astronauts on the Moon. He slipped his feet into gold-painted restraints outside the lunar module threshold and photographed Apollo 9 and the Earth 152 miles beneath him. Scott opened the Apollo hatch, poked his head into space, and took pictures of Schweickart while Rusty reciprocated.

As Spider approached the command ship for docking, Scott remarked: "You're the biggest, friendliest, funniest-looking spider I've ever seen." Spider's hollow drogue, expertly guided by McDivitt and Schweickart, found the mating probe on Gumdrop and a buzzer signalled the union of the spacecraft. "I haven't heard a sound that good for a long time," McDivitt exclaimed.

So, on March 7th, Spider had proved itself in space. When Apollo 9 splashed down in the Atlantic off Grand Turk Island, within three miles of the aircraft carrier that would retrieve the astronauts, there was renewed confidence that another lunar module could land on the Moon in 1969. Dr. Debus led a delegation of 2,000 KSC personnel who greeted the Apollo 9 astronauts when they flew into Cape Kennedy's Skid Strip the day after their landing.

President Nixon congratulated the astronauts in these words: "The epic flight of Apollo 9 will be recorded in history as 10 days that thrilled the world."

As the President expressed the nation's admiration to the astronauts, KSC crews transferred Apollo 10 from the Vehicle Assembly Building to Pad B. This would be the first launch from that site. This time the astronauts would fly to the Moon, separate the lunar module, called Snoopy, descend to within 50,000 feet of the lunar surface, then rendezvous and dock with the command ship and return to Earth. The prime crew had rehearsed patiently for months — Thomas P. Stafford, Commander; John W. Young, Command Module Pilot and Eugene A. Cernan, Lunar Module Pilot. All three were veterans of Gemini manned flights.

Kennedy's engineers had been hard at work preparing the launch vehicle and spacecraft since October, 1968 when Apollo 7 became the first U.S. three-man space mission. The backup astronaut crew, L. Gordon Cooper, Donn F. Eisele and Edgar D. Mitchell, had tested the spacecraft in altitude chamber runs as did the prime crew and helped to verify the flight status of the command, service and lunar modules. The launch window opened May 18th at 12:49 P.M. Eastern Daylight Time.

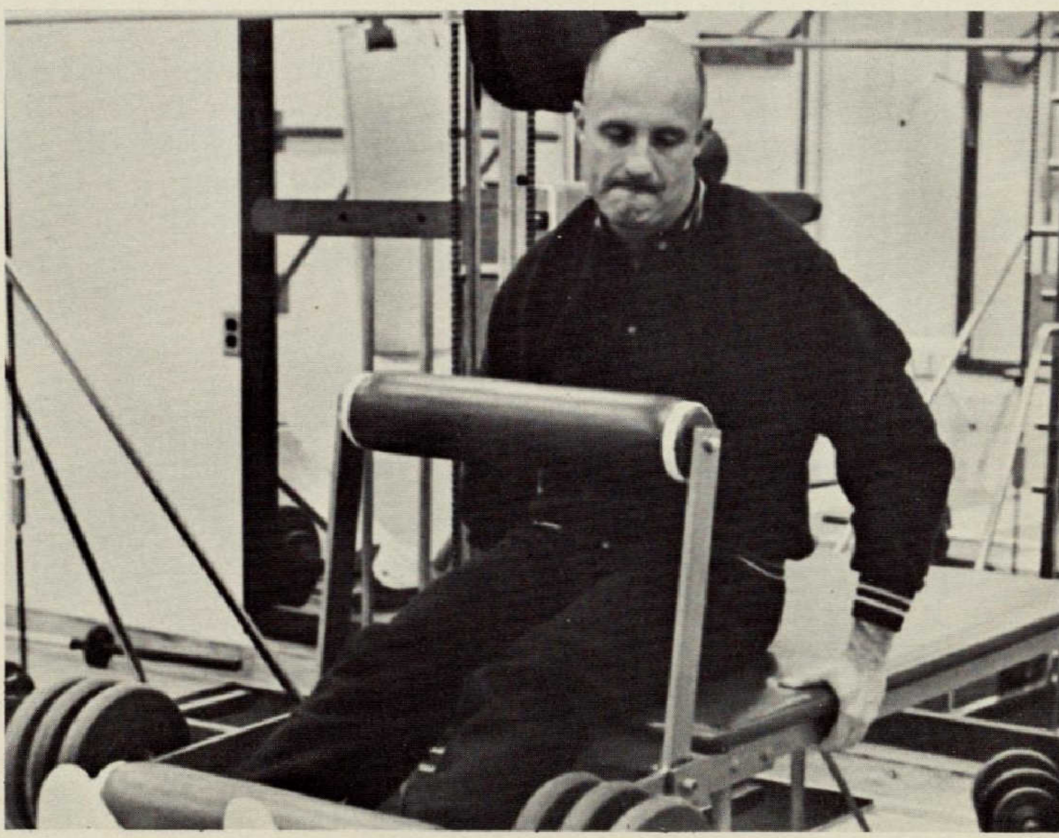
Don Phillips, the test supervisor, headed up the countdown team occupying Firing Room 3 of the Launch Control Center. He was assisted by Fritz Widick, lunar module test conductor; Skip Chauvin, Apollo

3⊕

test conductor and Gene Sestile, the launch vehicle test conductor. Continuing serial testing identified problems that were speedily corrected, such as interference with guidance and navigation systems of Apollo caused by the spacecraft radar heater transponder. The rollout had been held up one day due to interference between a phenolic block and the docking ring that, in turn, delayed mating the launch escape system atop Apollo. A newly designed pressurized case for the S band power amplifier was installed in the lunar module. As the flight readiness test was completed April 9, the launch escape tower had to be removed at the pad to permit modification of the docking ring area in Apollo and the liquid oxygen replenishment system was retested.

Following the fight readiness review April 23, launch operations personnel planned the critically important countdown demonstration test. During fueling of the first stage tanks, an inadvertent spill of some 5,000 gallons of fuel created concern as to possible internal damage resulting from overpressure. The forward dome of the RP-1, or jet fuel,

Apollo 10 Commander Thomas P. Stafford lifts weights during workout in gymnasium in the Manned Spacecraft Operations Building as he prepares for the mission that would take men within 8.5 miles of the lunar surface.



Above: Spacecraft countdown is monitored in ACE Station in Manned Spacecraft Operations Building during Apollo 10 test.

Below: Vice President Spiro T. Agnew and NASA Administrator Dr. Thomas O. Paine dined with the Apollo 10 astronauts at the Manned Spacecraft Operations Building the evening prior to the launch. Mr. Agnew presented an honorary Secret Service badge to Lunar Module Pilot Eugene Cernan. Command Module Pilot John Young and Commander Thomas P. Stafford, holding his badge, watch the presentation.

tank was visually inspected, subjected to dye penetrant check, and later to hydrostatic test. All the tests confirmed that the dome escaped damage that would have necessitated replacement and delayed launch.

The wet phase of the countdown demonstration was completed successfully May 5 and the dry phase on May 6. Then, while the astronauts intensively rehearsed rendezvous and docking in the simulators, the launch team prepared for the final countdown. It began at T—93 hours at midnight May 12 following the combined systems test of the lunar module. Vice President Spiro Agnew and Dr. Paine, NASA Administrator, occupied observers' chairs in the firing room during the terminal count which reached the launch instant exactly on schedule at 11 minutes before 1 P.M., EDT, Sunday, May 18.

Weighing nearly 6,400,000 pounds, since this was the first time Saturn V had carried its full payload of all three modules, the vehicle moved with seeming deliberation and then accelerated rapidly as the five powerful engines of the first stage gulped propellant at a rate of 15 tons per second. The vehicle functioned perfectly through roll sequence, jettisoning of the escape tower, first stage cutoff and second stage powered flight, cutoff of the second stage and third stage burn until it achieved orbit 11 minutes, 52.8 seconds after leaving Pad B. Two orbits were spent in checking out the spacecraft and then, over Australia, the crew received the "go" for translunar injection. The third stage engine was restarted, burning for 5 minutes 42 seconds, increasing the velocity from 17,400 miles per hour to 24,250 miles per hour.

John Young separated Apollo from the adapter enclosing the lunar module in a protective shroud atop the third stage and maneuvered to a point 50 feet ahead. Then he pitched the command ship 180 degrees so that the cone end with its docking probe pointed toward the lunar module. Employing the small thruster rockets, Young eased the probe into the docking collar and the ten latches clicked into place, firmly connecting the spacecraft. Then the pilot maneuvered the spacecraft clear of the third stage, which was guided around the back of the Moon and wound up in solar orbit.

The docking operation was seen in superb color from Earth as Cernan photographed the approach to the lunar module. Two hours later he turned the camera on Earth so that men might see their planet from thousands of miles in space. From there on to the Moon, the outward journey proceeded almost exactly as planned. To enter lunar orbit, the service propulsion system was ignited in retrofire mode to slow its velocity to approximately 3,600 miles per hour so that it would be captured by the Moon's gravitational field. Subsequently the orbit was circularized to approximately 60 nautical miles. During the third orbit, the crew turned on the television camera again and, for the first time, Earth

viewers saw the Moon's surface in color.

May 22 turned out to be an action-packed day. Commander Stafford and Lunar Module Pilot Cernan separated their craft from the command ship on the dark side of the Moon, emerging to inform Earth they had done so and were flying formation, or "station keeping" at a range of 50 feet from Apollo. By mid-afternoon, having run through an exhausting checklist, the two astronauts were ready for descent. The descent engine was fired in braking mode at 4:35 P.M. EDT and moved into an orbit at which they would approach closer to the Moon than man had ever been. An hour later, Cernan called Mission Control and reported, "Hello Houston, we is down among it!" The spacecraft had reached a point of 8.4 nautical miles above the Sea of Tranquility which had

Photograph of unidentified crater on far side of Moon obtained as lunar module descended to 8.4 miles above the surface.

been selected as the landing site for Apollo 11, provided the Apollo 10 mission succeeded.

In rapid fire sequence, Stafford and Cernan called out their description of the surface. They said the landing site was "pretty smooth, like wet clay, like a dry river bed in New Mexico or Arizona." They also spoke of "enough big boulders to fill Galveston Bay." At the low point of their second swing around the Moon, Stafford and Cernan prepared to fire the ascent engine to propel them up to rendezvous and dock with Charlie Brown, their nickname for the command ship. Before firing the motor, they had to separate the descent stage and just before this action, the lunar module, or Snoopy, suddenly gyrated. Stafford immediately took manual control and restored proper orientation. Then the descent stage was jettisoned and the module stabilized. Later analysis indicated the problem resulted from a malfunction in the backup guidance system.

A 15-second burn of the ascent stage engine hurled Snoopy into a looping orbit above and behind Charlie Brown. From a maximum separation of 320 nautical miles, they closed to within 38 nautical miles in about two and one-half hours. Then three burns of the reaction control thrusters brought the lunar module into docking range. Young flew Apollo expertly into the docking mode which was completed at 11:11 P.M. Fourteen minutes later he was rejoined by Stafford and Cernan. The two astronauts had successfully flown their module eight hours, standing all the while, sustained by a web of belts and harness. With the tunnel secured, the lunar module was cast loose and directed into solar orbit.

More color telecasts ensued and next morning, while on the far side of the Moon, the crew fired Apollo's engine to achieve velocity necessary to escape lunar gravity and enter the narrow corridor along which they would return to Earth. So precise was the burn that the speed achieved was just .4 mile per hour less than planned. Mid-course corrections permitted in the flight plan were eliminated.

Eight days and three minutes after leaving Pad B, Apollo 10 splashed down three miles from the Pacific aiming point 450 miles east of Samoa. The dress rehearsal for the lunar landing had been completed.

Following the customary debriefing period, the Apollo 10 crew undertook a full schedule of public appearances but, at their option, delighted the launch team by arranging a return visit to the Kennedy Space Center June 12. Even these intrepid Moon voyagers expressed amazement as they walked into the transfer aisle of the Vehicle Assembly Building that morning, greeted by Rocco Petrone in the absence of the Center Director, for 10,000 people jammed the cavernous building to cheer their return. Later they lunched in Titusville, participated in a

parade in Cocoa Beach, and concluded the day with a community dinner in their honor at which they described their trip to and from the Moon. The crew announced establishment of the Apollo 10 Scholarship Fund at Florida Institute of Technology and made the initial contribution to the fund.

Speaking to the Center personnel, Stafford said, "There are only a few ways in the English language that we can say thank you, but from the three of us, we can never say that enough to all of you people." To which John Young added, "The difference between mediocrity and greatness is this launch test team . . . trouble shooting in real time getting the vehicle ready under the very real pressure of trying to meet the window, and by golly, you made it. You're the greatest and we thank you." Then Cernan concluded by saying "This is a great team, a fantastic team. You're not on our team, we're on your team, and all I can say is that we're proud to be on it."

Having expressed their thanks, the three men walked the long walk through the transfer aisle, shaking hands, accepting congratulations and beaming their pleasure. It was notable reunion of extraordinary people.

Astronauts Thomas Stafford, John Young and Eugene Cernan wave to the 10,000 Kennedy Space Center employees who assembled in the Vehicle Assembly Building on their return to Brevard County following the Apollo 10 mission. Color photographs of the Apollo 10 launch were gifts of KSC.

XIII

Eagle Has Landed

LAUNCH operations proceeded so rapidly at Kennedy Space Center between October 1968 and July 1969—four manned Apollo missions, two of them to the Moon, enjoyed incredible success — that it was difficult for those intimately connected with the effort to understand the ultimate significance of their work. They went about preparations for each mission methodically, with painstaking care and outwardly calm demeanor that may have concealed an undercurrent of excitement. They knew the payoff for eight years of unremitting diligence and toil was at hand. History could make of the events what it chose, but these people and the staffs of Mission Control, the worldwide tracking network, the recovery fleet and the astronauts were determined to succeed.

For this, the most difficult of all missions, NASA selected three veterans of Gemini flights, Neil A. Armstrong as Commander — the only civilian member of the crew — Michael Collins, Command Module Pilot, and Edwin E. Aldrin, Jr., Lunar Module Pilot. The backup crew consisted of James A. Lovell, Commander and his Apollo 8 crewmate, William A. Anders, Command Module Pilot, and Fred Haise, Jr., Lunar Module Pilot. Anders would leave the program shortly to become Executive Secretary of the National Aeronautics and Space Council by Presidential appointment.

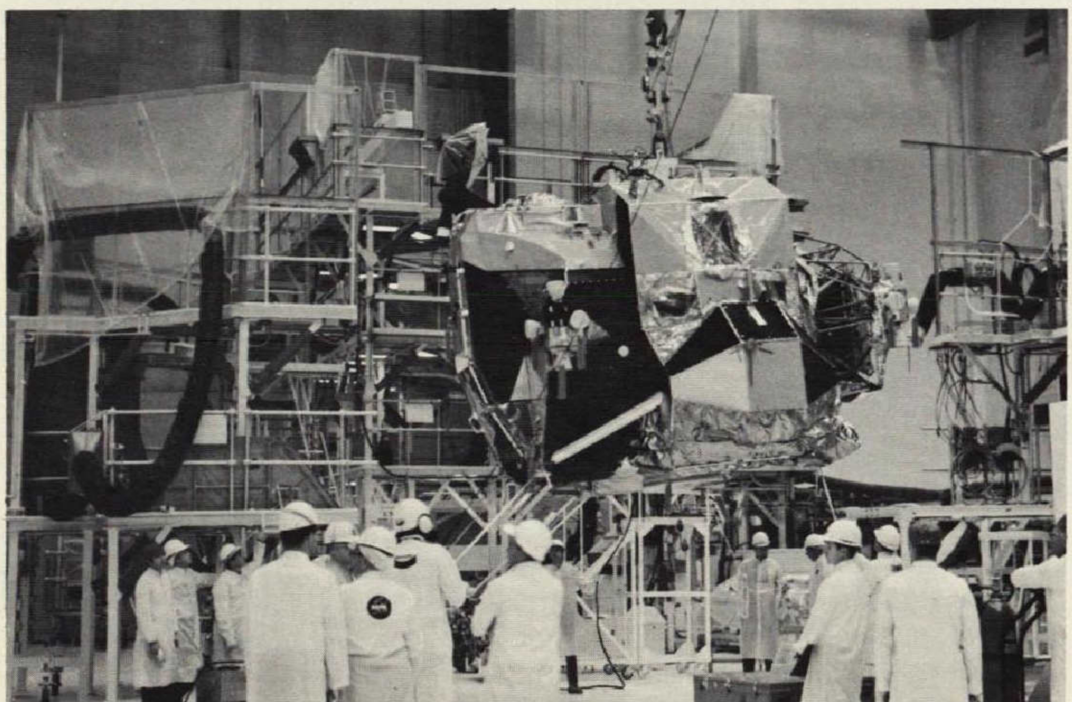
KSC began to receive Apollo 11 stages in early January while checking out, assembling and testing Apollos 9 and 10. The lunar module, later named Eagle by the crew, arrived first followed by the Apollo command and service modules which were named Columbia. Next came the third, or S-IVB stage of Saturn V, then the S-II or second stage which underwent more rigorous inspection than customary because the barge transporting it from California encountered stormy weather and rough seas. Then the powerful first, or S-1C stage, was offloaded at the Barge Terminal and finally the instrument unit was flown in from

Huntsville, Alabama February 27. Bay 1 of the Vehicle Assembly Building and Mobile Launcher 1 were selected for erection and checkout that would extend for two months. This was the same launcher and same bay employed for Apollo 8. Control circuitry of Firing Room 1, Launch Control Center was connected with the stages during erection, or stacking, beginning February 21 and concluding April 14 when the Apollo spacecraft topped off the configuration.

During March the prime and backup crews participated in testing Columbia and Eagle in the altitude chambers of the Manned Spacecraft Operations Building. One lunar module test had to be repeated due to a problem in the primary water boiler system that was soon corrected. An additional altitude chamber run was conducted to straighten out procedures and verify portions of the environmental control system. Docking tests of the two spacecraft were carried on in mid-April. The spare flight control computer was installed in Saturn V's instrument unit and revalidated. Eagle's water glycol system had to be drained and reserviced when engineers detected air entrapped in the system.

One problem which developed during lunar module checkout vividly demonstrated that even among the engineering marvels of the Center, the human body has a place in the scheme of things. The urgent need to

Apollo 11 lunar module ascent stage is moved from work stand to cleaning positioner during preparation in Manned Spacecraft Operations Building.



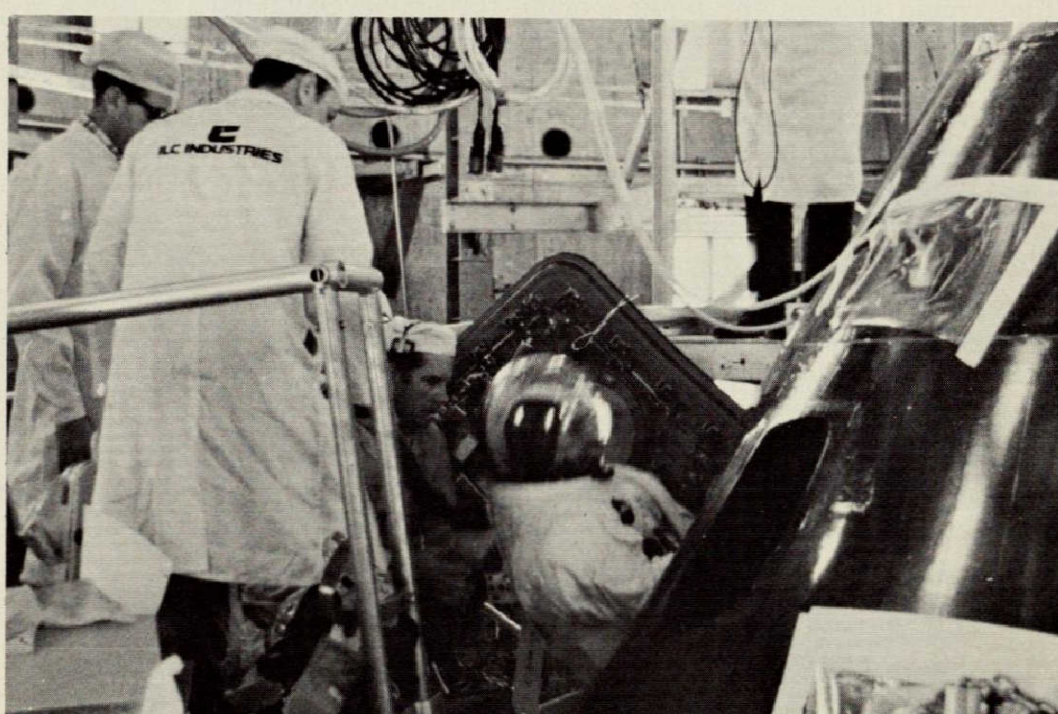
replace actuators in the descent stage became apparent and it was equally apparent that access to the devices might involve demating both stages, which would very likely have delayed the launch. Grumman, the lunar module builder, called in William Dispenette from the home plant in Bethpage, L.I. Dispenette is 6 feet, 2 inches tall and weighs about 150 pounds. He was able to squirm into the descent stage, bending his body around the engine, and change the actuators. Two local Grumman employees, Steve McGullam, 5 feet, 11 inches and 155 pounds and Charlie Tanner, 5 feet, 7 inches and 135 pounds "soaking wet" later managed the same, neat trick — the lunar module did not delay the flight.

After fuel cells were installed in Columbia, Eagle was powered up for combined systems test. Then the docking probe was installed and checked out, the launch escape system mounted on Apollo, ordnance charges were placed aboard Saturn V and the crawler picked up the 12,000,000-pound assembly and started for Pad A at 12:30 P.M.

During the debriefing following the Apollo 10 mission the crew reported a problem encountered in flight. Insulation material came loose within the tunnel connecting their spacecraft and floated about inside the command ship. It was decided to remove Columbia's tunnel hatch and strip the insulation.

As the Center approached the Apollo 11 launch, Dr. Kurt Debus

Astronaut Neil Armstrong enters command module prior to test in Manned Spacecraft Operations Building altitude chamber.



reminded the Government-industry launch organization that "the final steps can be most critical. I know that you will be equal to the task." Ray Clark, technical support director, pledged that his group that included Federal Electric Company and Bendix would function at maximum effectiveness. Walter Kapryan, deputy launch director, observed that "everything we have done over the past several years is culminating in this mission. We are moving toward launch based upon experience but not with over-confidence. We will be ready."

Donald R. Oswald supervised KSC inspectors checking the contractors' work within the Saturn V stages. Some tools were tethered while in use to insure removal. Every non-flight item carried a bright red tag so that it would not be overlooked when the stages were buttoned up for flight.

William H. Schick was the Government's test supervisor. Norman Carlson, launch vehicle test conductor, maintained constant contact with his industry counterparts: Robert Verdier, Boeing first stage test conductor; Tom Martin, North American Rockwell, second stage; Ron Shane, McDonnell Douglas, third stage and Tom Kitchens, IBM, instrument unit. C. A. Chauvin, KSC spacecraft test conductor, worked with Stan Jensen, representing Apollo's builder, North American Rockwell, while Fritz Widick, KSC lunar module test conductor, dealt with Mark Goodkind of Grumman. Gordon Artley served as test support manager.

As the preparatory work moved into June, the experiment package that would ride on the lunar module for emplacement on the Moon was checked out along with other functional systems. A flight readiness test ran off smoothly June 6. Technicians completed flushing the liquid oxygen tank dome of the first stage and modified Eagle's forward hatch. Next, the mission director, George Hage, and the Apollo Program Director, Lt. Gen. Phillips, conducted the flight readiness review June 17. All the organizations involved in the mission reported their status. On that day also the launch team completed leak and functional testing of the spacecraft and began loading hypergolic fuel. A defective electrical connector in one of Eagle's control panels had to be replaced and retested. Eagle's heat shield was repainted to cut down reflectivity, solving a false lock of the landing radar.

Cavernous fuel tanks of the first Saturn V stage were filled the last week of June and hypergolic servicing of Columbia was completed. Ordnance charges were placed in the spacecraft. More checks on Eagle's hatch confirmed flight readiness.

The countdown demonstration test, during which vehicle and spacecraft would be fueled, powered up and counted down for launch, stopping just short of the automatic ignition sequence, got under way June 27 and moved steadily to completion July 2. Then the rocket's tanks were

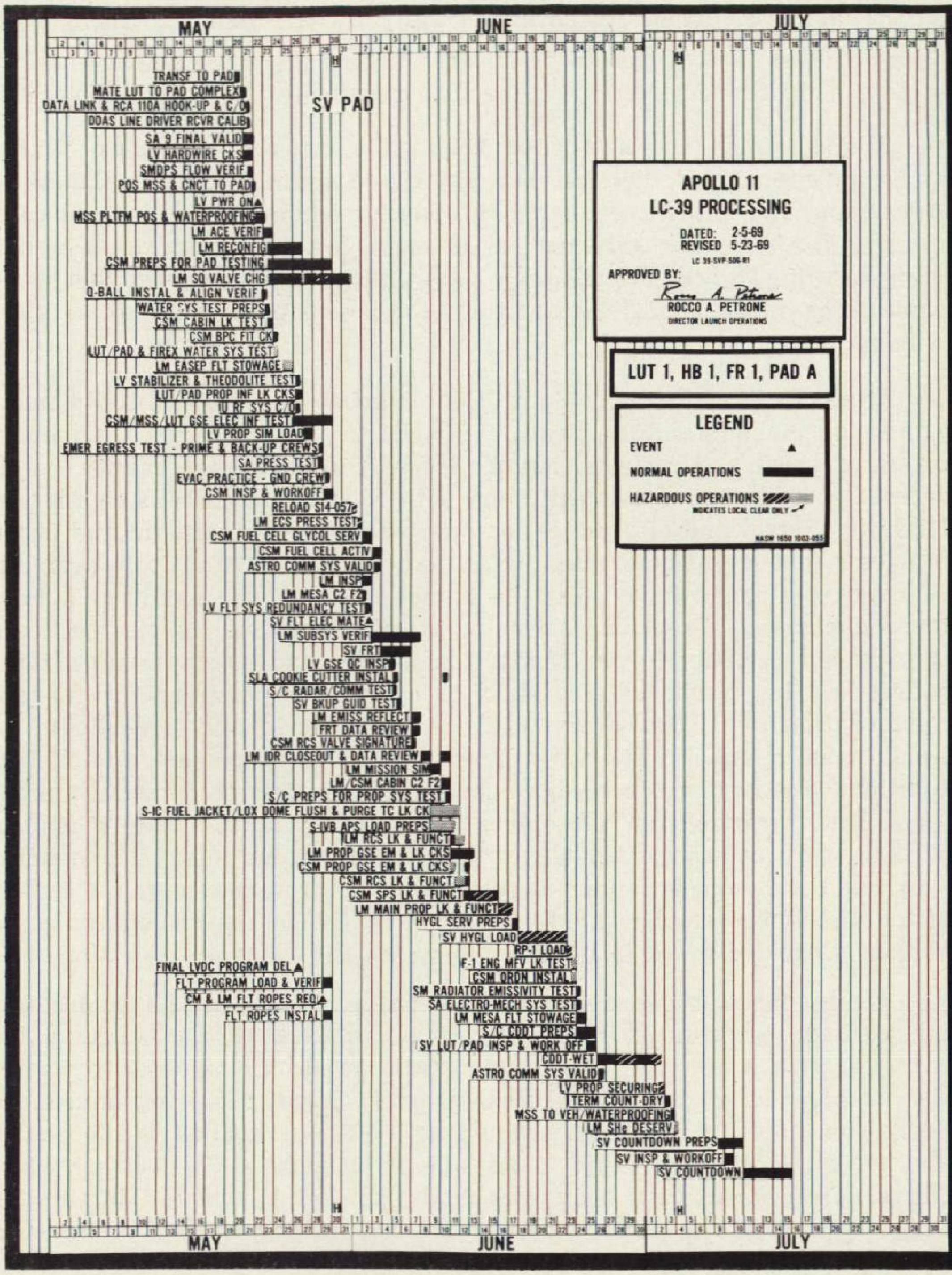
drained and a dry test, with Astronauts Armstrong, Collins and Aldrin participating, followed next day. More tasks remained to be performed. Modifications were required to Eagle's upper primary strut and the landing gear. Scientific experiments carried in the MESA package were checked. A shift in a gyroscope aboard Eagle's guidance and navigation system had been detected. The inertial measuring unit was replaced.

While launch crews worked round the clock at Complex 39 the astronauts rehearsed their mission again and again in the simulators — Armstrong and Aldrin occupying the lunar module and Collins the command ship. The crew returned to Houston for family farewells and a press briefing July 5. Dr. Charles Berry, their physician, was taking no chances on infection. The astronauts faced the press through a glass window.

Weeks before, Kennedy Space Center spokesmen called in city managers, police chiefs and the Brevard Sheriff to alert them to the expected influx of press and official visitors. Herbert Johnson, the county's civil defense coordinator, developed plans with Sheriff Leigh Wilson, Florida Highway Patrol and city police to cope with increased traffic and other problems that might be created by as many as 1,000,000 visitors arriving in Brevard County to witness the launch. Dr. Debus organized a task force comprised of representatives of the Eastern Test Range, the State Department, security forces, NASA's legislative and international affairs office, and his public affairs staff to coordinate planning for the accommodation of 19,000 press, distinguished guests and dependents of Apollo team members. The U.S. Department of Transportation published additional restrictions on bridge openings in Brevard to forestall traffic jams. KSC arranged for helicopters to fly in key launch team members if they were otherwise unable to reach their work sites. The traffic snarls did not impede launch preparations. As it turned out, the influx of tourists while very large did not exceed the 700,000 mark. Many people obviously decided it would be wiser to watch the event on television.

Flight batteries were installed in Eagle as the fateful countdown approached. It began at 8 P.M. July 10 at T minus 93 hours, aiming for liftoff at 9:32 A.M. July 16. The schedule allowed built-in holds to permit the launch team to rest provided hardware problems requiring immediate resolution did not occur. There would be a 12-hour hold at T—66 hours, another of 16 hours at T—38 hours, one of 11 hours at T—9 hours when the terminal phase would commence, and again for 1 hour and 30 minutes at T—3 hours, 30 minutes when the astronauts prepared to occupy Columbia.

Firing Room 1 was staffed by 463 operating personnel. The room has 14 rows of display and control consoles, vertical recording and monitoring racks, and there is an adjacent room housing the digital computer



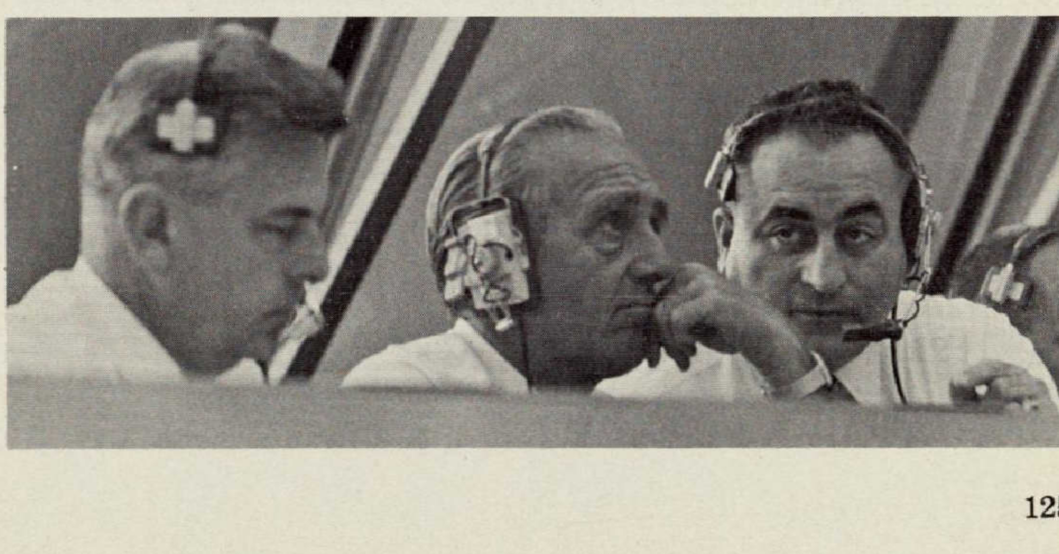
Processing schedule for Apollo 11 at Complex 39.

connected with a similar computer in the base of the mobile launcher on which Apollo 11 waited. Sixty-eight NASA and contractor supervisors occupied the first four rows nearest the sloping windows that look out on the launch complex. Seated at the top row were Isom A. Rigell, KSC chief engineer; Lee B. James, Saturn V program manager for Marshall Space Flight Center; Andrew J. Pickett, KSC test operations manager; Dr. Hans F. Gruene, KSC director of Saturn V operations; Rocco A. Petrone, the launch director; Dr. Kurt Debus, Center Director; Walter J. Kapryan, Petrone's deputy; John J. Williams, KSC spacecraft director and George M. Low, Apollo program manager for the Manned Spacecraft Center. KSC's information officer, Jack King, sat at the end console.

Watching and listening intently to the countdown from an observation room along the side were Dr. George E. Mueller, Associate NASA Administrator; Lt. Gen. Phillips, his deputy Chester M. Lee; Dr. Wernher von Braun, MSFC Director; his deputy, Dr. Eberhard Rees; Miles Ross, KSC deputy director for operations; Rear Admiral R. O. Middleton, KSC Apollo Program Manager, and Astronaut James McDivitt. Dr. Thomas O. Paine, the NASA Administrator, looked on from across the room. Nearby was Julian Scheer, the Assistant Administrator for Public Affairs.

Boeing engineers, 140 strong, occupied rows of consoles linked to the S-1C stage and mechanical ground support equipment. North American Rockwell had 60 engineers manning consoles connected with the S-II stage while McDonnell Douglas assigned 45 engineers to consoles monitoring the S-IVB stage. Ninety IBM engineers manned three rows of consoles hooked up to the instrument unit, stabilization and guidance systems, and flight control. Five miles to the south two automatic checkout stations in the Manned Spacecraft Operations Building monitored Columbia and Eagle. Raymond Klinect was ACE Station 1 manager for

Walter J. Kapryan, Dr. Kurt Debus and Rocco A. Petrone observe progress of Apollo 11 countdown in Launch Control Center.



the command and service modules working with Earl Turner of General Electric Company. Nevin Ball supervised Station 3, connected with Eagle, working with Eric Simon of GE. KSC's George Page supervised both stations. On the first floor of the Launch Control Center technical support personnel manned consoles monitoring propellant flow, life support and other ground systems. Engineers in the Central Instrumentation

COUNTRIES REPRESENTED AT APOLLO 11 LAUNCH

3,497 ACCREDITED - FROM 56 COUNTRIES

UNITED STATES	2,685	COSTA RICA	7	IRELAND	2
JAPAN	118	SWEDEN	7	LEBANON	2
ENGLAND	82	ISRAEL	6	MALTA	2
ITALY	81	CZECHOSLOVAKIA	5	ROMANIA	2
FRANCE	53	DENMARK	5	YUGOSLAVIA	2
ARGENTINA	52	NICARAGUA	5	EGYPT	1
MEXICO	51	PANAMA	5	GUATAMALA	1
GERMANY	44	PERU	5	HAITI	1
CANADA	38	ECUADOR	4	HONDURAS	1
SPAIN	27	FINLAND	4	ICELAND	1
BRAZIL	26	IRAN	4	MONACO	1
AUSTRALIA	25	SOUTH AFRICA	4	NEW ZEALAND	1
SWITZERLAND	20	BOLIVA	3	NORWAY	1
BELGIUM	19	GREECE	3	RHODESIA	1
KOREA	15	LUXEMBOURG	3	SOMALIA	1
NETHERLANDS	10	TURKEY	3	SWAZILAND	1
CHILE	9	URUGUAY	3	WALES	1
VENEZUELA	9	INDIA	3		
COLOMBIA	8	ANGOLA	2		
		AUSTRIA	2		

Facility recorded measurements from Saturn V and monitored the intricate communications network tying together all the operating stations.

In early evening July 14, the astronauts sat in front of television cameras in the KSC News Center for the final press interview before launch. Twelve miles away, a panel of reporters quizzed them for half an hour. Walter Cronkite of CBS represented the networks, Al Rossiter of United Press International, the wire services; Everett Clark, Newsweek, the periodicals and Joel Shurkin of Reuters, the foreign press. Twenty-four hours before launch the number of press accredited by NASA soared to 3,400.

During the night of July 15, the pad area and Apollo 11 were brilliantly illuminated by xenon lights. The crawler lumbered up the pad incline, picked up the Mobile Service Structure and carried it to a parking area a mile away. In the early hours of July 16 liquid hydrogen was pumped into the tanks of the second and third stages. The rocket was AS-506, indicating the sixth Saturn V vehicle. It carried Command Service Module 107, Lunar Module 5 and SLA-14. It weighed 6,484,300 pounds and towered 363 feet above the launcher from which the first three astronauts to orbit the Moon had begun their mission seven months before. The first stage would consume 4,670,300 pounds of jet fuel in 161 seconds, the second stage would burn 971,540 pounds of liquid hydrogen in 389 seconds, while the third stage required 223,900 pounds of liquid hydrogen for two burns.

Flight Crew Director Deke Slayton awoke the astronauts at 4:15 A.M. They breakfasted on orange juice, steak, scrambled eggs, toast and coffee, then began suiting up at 5:35 A.M. They left the Manned Spacecraft Operations Building for the pad eight miles away at 6:28 A.M. Arriving at Pad A, they rode the launcher elevator up to spacecraft level, walked across the connecting swing arm, and Armstrong entered Apollo at 6:54 A.M. With the closeout crew assisting, Collins joined him five minutes later in the right couch, then Aldrin climbed into the center seat. Two minor problems which developed in ground equipment while the astronauts were en route to the pad had been corrected — a leaky valve and a faulty signal light. Half a mile to the west, protected by a sand bunker, 14 rescue personnel stood watch. They remained on station until Apollo 11 was on its way. Equipped with armored personnel carriers, and wearing flame protective gear, they could move to the pad quickly in emergency if the astronauts required help.

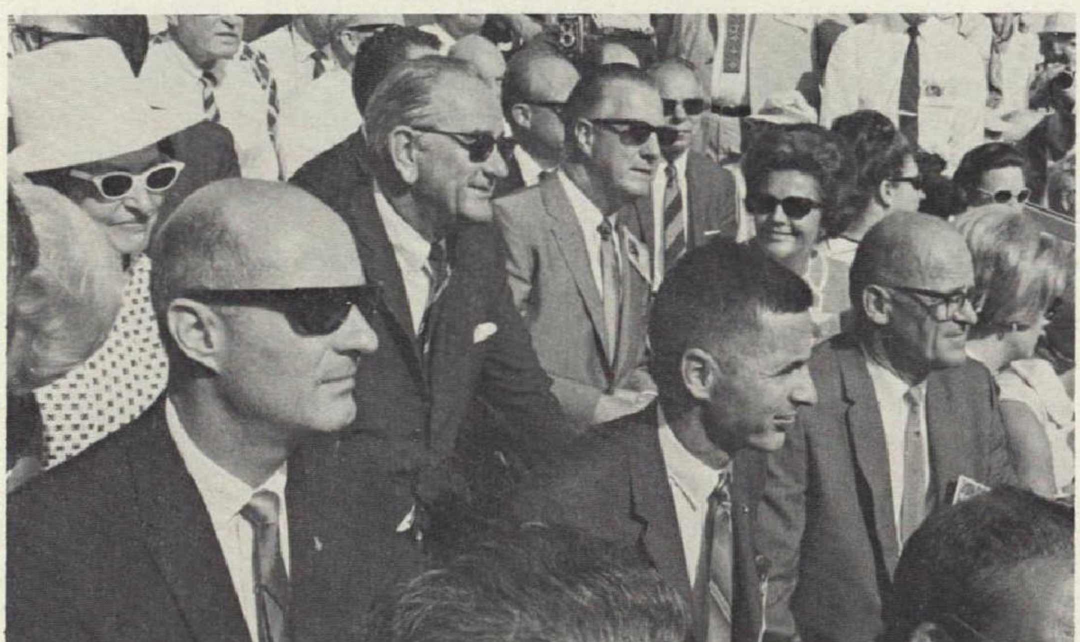
At the Press Site, close to the Launch Control Center, the press corps augmented for this occasion by nearly 900 newsmen from overseas waited and watched. Some spent the night there. Five thousand distinguished guests, hundreds of whom arrived that morning by jet aircraft, gathered at the viewing site north of the Vehicle Assembly Building.

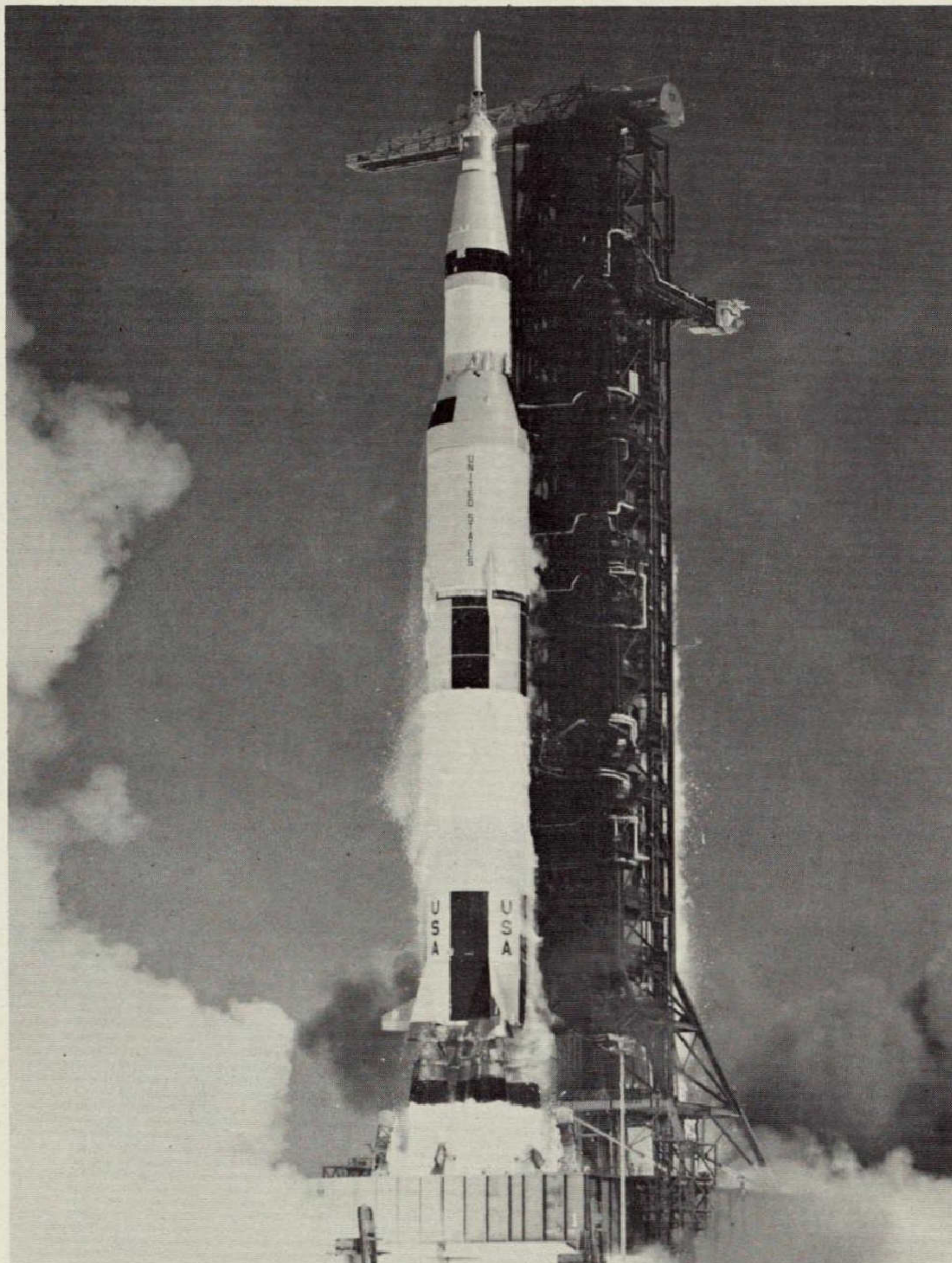
Among them were Vice President Spiro Agnew and Mrs. Agnew, former President Lyndon B. Johnson and Mrs. Johnson, escorted by Deputy Center Director Albert F. Siepert, Mrs. Debus, Mrs. David Jones, wife of the Eastern Test Range commander, Mrs. Paine and Mrs. George Mueller.

The Army Chief of Staff, General William Westmoreland, was in the crowd. So were 33 U.S. Senators, 206 Congressmen, 56 Ambassadors, the Secretaries of Commerce, Interior, Transportation, and Health, Education and Welfare. Semon E. Knudsen, president of Ford Motor Company; Virgil E. Boyd, president of Chrysler; other industrialists, 14 Governors and Dr. Lee DuBridge, the President's science advisor, were on hand. Mrs. Neil Armstrong looked on from a yacht anchored in the Banana River six miles from the launch site. Ten thousand more visitors were parked along Kennedy Parkway — they were employees of KSC, MSC, MSFC, and NASA Headquarters with their families. It was a beautiful morning, bright sunshine, a few fleecy clouds, winds of 10 knots from the southeast, and by 9 A.M., very warm.

The Apollo access arm was retracted at 9:27 A.M., or T—5 minutes

Former President and Mrs. Lyndon B. Johnson and Vice President and Mrs. Spiro T. Agnew in the viewing stands near the Vehicle Assembly Building for the launch of Apollo 11. In the foreground are astronaut Thomas Stafford, now Chief, Astronaut Office, MSC; astronaut William Anders, now Executive Secretary of the National Aeronautics and Space Council; and Albert F. Siepert, then KSC Deputy Director for Center Management.





Apollo 11 lifted off precisely on time at 9:32 a.m., July 16, 1969.

in the count. At 4 minutes the "cleared for launch" command could be heard plainly. The countdown became automatic at 3 minutes, 20 seconds — from there on, computers took over. The ignition sequence commenced at 8.9 seconds when the first engine roared into life. At T—zero, all five engines had built up full thrust and the computer signalled the holddown arms to release the vehicle. Apollo 11 lifted off at 9:32:0.624 EDT. Cheering throngs, some teary eyed, followed its course as the rocket slowly gathered momentum, executed a yaw maneuver to avoid collision with the umbilical tower, and then a pitch and roll maneuver to achieve proper flight attitude. Saturn V steered eastward over the Atlantic on the flight azimuth of 72 degrees. Onlookers saw the first stage engines shut down at the planned instant, watched the stage separate, and heard the announcement that the second stage engines were running as scheduled. They could not see flame for liquid hydrogen burns without it.

Apollo 11 attained Earth orbit 11 minutes and 49 seconds after liftoff — a mass of more than 140 tons circled the globe traveling 17,500 miles per hour. Vice President Agnew drove to the Launch Control Center and spoke to the launch team as he had following the launches of Apollos 9 and 10. He said:

Vice President Agnew went to the Launch Control Center to congratulate the team on the successful Apollo 11 launch. Here he discusses the operation with NASA Administrator Dr. Thomas O. Paine.

"This is almost getting to be routine, to come here and congratulate you on the advent of another flight. It looks like it is as perfect as the others you've put together. This was my first time to witness one from the outside. It's a different ball game out there. You get more of the sense of the power of these rockets. I couldn't help thinking of you, the people here and throughout NASA, who have done such a brilliant job of putting together the combined efforts behind these three gentlemen who are off on this historic mission."

The Vice President said he believed that the United States should next plan to fly men to Mars. Then he added, "this program is the future of our country. The gains that come from it are going to be the greatest fallout for the advancement of all our citizens than anything else we could do. Together, we'll do the job."

Among the lines of vehicles moving out of the Center after launch were those carrying astronauts and their wives who had viewed the event. Some had flown in space, some were still to fly; among them Alan Shepard, Bruce McCandless, Dr. Robert Parker, Dr. Joseph Allen, Vance Brand, Dr. Donald Holmquest, Fred Haise, Dr. Edward Gibson, Dr. Curtis Michel, Stuart Roosa, Gordon Cooper, Pete Conrad, James Lovell, Alan Bean, Charles Duke, James Irwin, Russell Schweickart, Dr. Phillip Chapman, J. L. Swigert, Eugene Cernan, Joe Engle, Ronald Evans and some personal friends including General Charles Lindbergh.

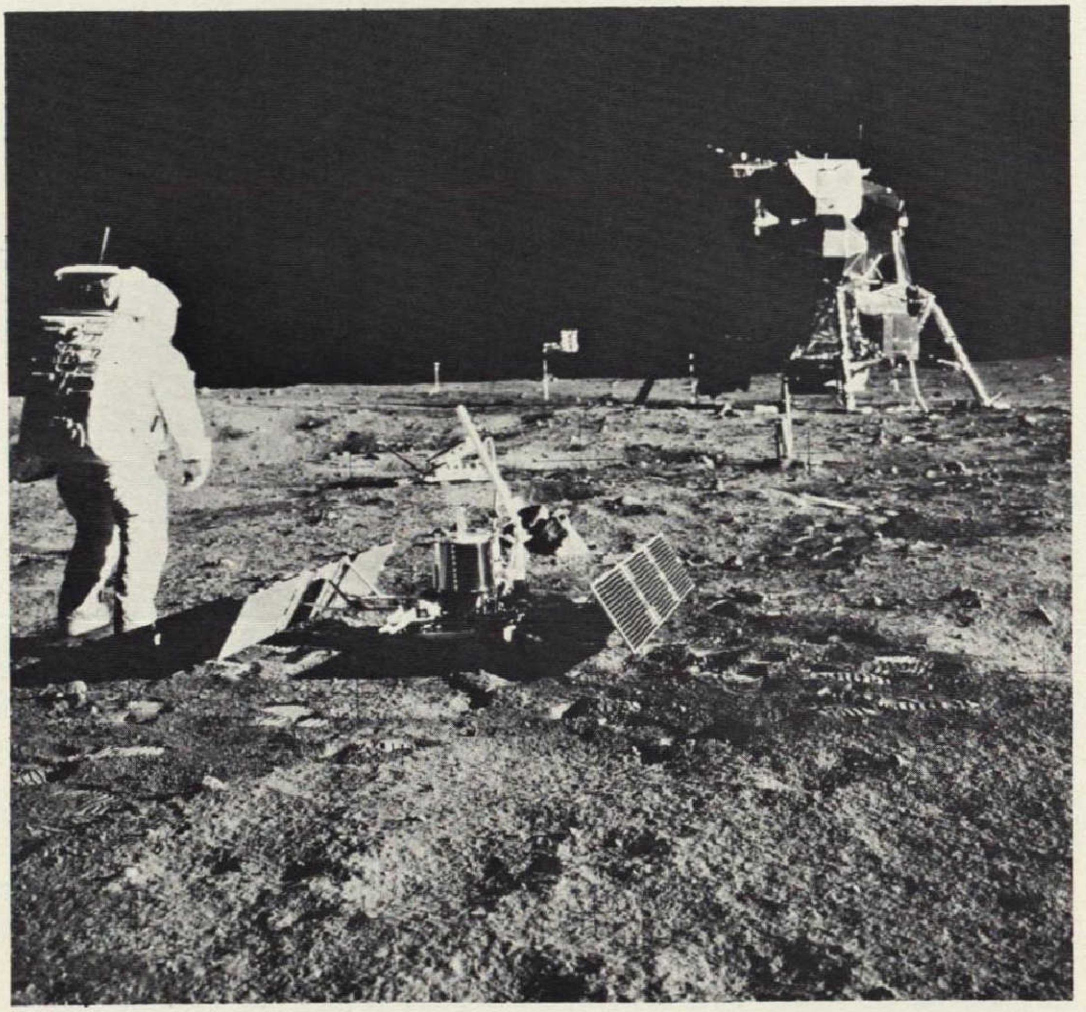
Cleared to proceed to the Moon, the astronauts fired the S-IVB engine again at 12:22 P.M., increasing their velocity to 24,000 miles per hour. Collins separated Columbia, turned the spacecraft around, docked with Eagle and pulled the lunar module away from the S-IVB which was subsequently guided into a slingshot path beyond the Moon and entered solar orbit. En route to their destination, the crew thrilled Earth observers with live color telecasts, the finest yet recorded in space flight.

During the third day, Armstrong and Aldrin romoved the docking probe and drogue and opened the tunnel hatch. They entered Eagle to perform housekeeping chores and check the equipment. Their activities were seen by millions in the United States, Japan, South America, Canada and Western Europe.

On July 20, Sunday in the United States, Armstrong and Aldrin occupied Eagle, powered up the spacecraft, and deployed the landing legs. The two spacecraft separated at 1:46 P.M. Collins fired Columbia's rockets to move about two miles away. Flying feet first, face down, Armstrong and Aldrin fired Eagle's descent engine at 3:08 P.M. Forty minutes later, as Columbia emerged from behind the Moon, Collins reported what had occurred, commenting that "Everything's going just swimmingly." The two astronauts piloting Eagle guided the spacecraft into elliptical orbit with a perilune of 8.5 nautical miles from the Moon. Armstrong throttled the engine at 4:05 P.M. to slow its descent.

As the Moonscape came into clearer view, Armstrong saw that Eagle was approaching a crater almost as large as a football field. He took over manual control and steered towards a less formidable site — at Mission Control, physicians noted his heartbeat increased from the normal 77 to 156. While Armstrong manipulated the controls, Aldrin called out altitude readings: "Seven hundred and fifty feet, coming down at 23 degrees . . . 700 feet, 21 down . . . 400 feet, down at nine . . . Got the shadow out there. . . 75 feet, things looking good . . . lights on . . . picking up some dust . . . 30 feet, 2 1/2 down . . . faint shadow . . . four forward . . . drifting to the right a little . . . contact light . . . O.K. Engine stop." As the probes beneath three of Eagle's four footpads touched the surface, a light flashed on the instrument panel. The world

Astronaut Neil Armstrong photographed Edwin Aldrin as he deployed Apollo scientific experiments package on the lunar surface. The U.S. Flag and Eagle are visible in the background.



heard Armstrong's quiet message:

"Houston, Tranquility Base here. Eagle has landed."

Later the crew explained that while some distance from the surface, fine dust blew up around the spacecraft and obscured their vision. They felt no sensation at the moment of landing. There were many tasks to be performed and they set to work after telling Earth what they could see from Eagle's windows. At 6 P.M. Armstrong called to recommend that the walk on the Moon should begin about 9 P.M., or earlier than originally planned. Later than proposed, but still five hours ahead of schedule, Armstrong opened the hatch and squeezed through it at 10:39 P.M. He wore 84 pounds of equipment on his back containing the portable life support and communications systems — on the Moon, the weight was 14 pounds.

Wriggling through the hatch, Armstrong cautiously proceeded down the nine-step ladder, the last 10 feet to the surface. He paused at the second step to pull a ring which deployed a television camera, mounted to follow his movements as he climbed down. At 10:56 P.M. Armstrong planted his left foot on the Moon, saying as he did: "That's one small step for a man, one giant leap for mankind."

Later, as he described the powdery lunar surface material, and collected soil samples, he remarked, "It has a stark beauty all its own. It's like much of the high desert in the United States." Aldrin emerged from Eagle and joined Armstrong at 11:11 P.M. For the next two hours they collected rock samples, set up scientific apparatus, erected the American flag, took pictures, and loped easily about the surface while an estimated 600,000,000 Earth viewers watched the incredible spectacle.

President Richard Nixon addressed the explorers while they listened:

"Neil and Buzz, I am talking to you by telephone from the Oval Room of the White House. And this certainly has to be the most historic telephone call ever made. I just can't tell you how proud we all are of what you have done. For every American this has to be the proudest day of our lives. And for people all over the world, I am sure they, too, join with Americans in recognizing what a feat this is. Because of what you've done, the heavens have become part of man's world. And as you talk to us from the Sea of Tranquility, it inspires us to double our efforts to bring peace and tranquility to Earth. For one priceless moment in the whole history of man, all the people on this Earth are truly one. One in their pride of what you have done. And one in our prayers that you will return safely to Earth."

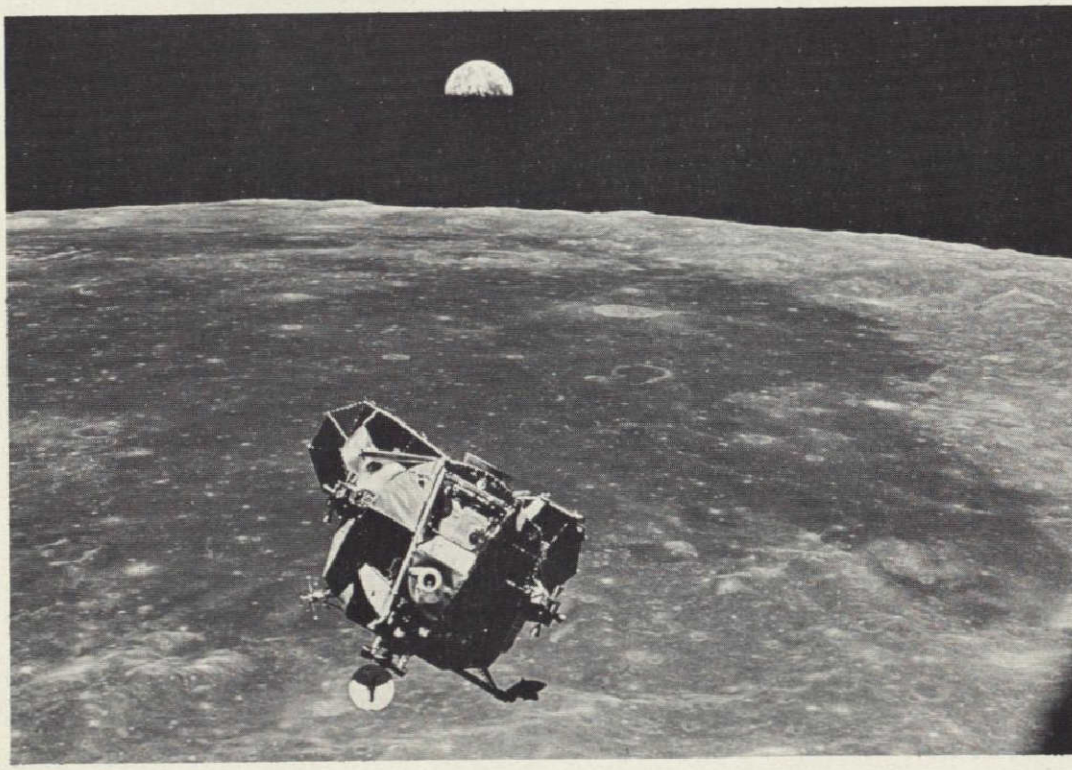
Armstrong replied: "Thank you, Mr. President. It's a great honor and privilege for us to be here representing not only the United States

but men of peace of all nations. And with interest and a curiosity and vision for the future. It's an honor for us to be able to participate."

The astronauts carried with them two other U.S. flags, to be flown later over the Capitol, the flags of the 50 States, the District of Columbia and U.S. territories, the United Nations flag, and those of 136 foreign nations — all returned to Earth for presentation later.

Having completed their assigned tasks, the astronauts reentered Eagle on instructions from Mission Control, closing the hatch at 1:11 A.M. July 21. They tried to rest but could not. Eagle was cold and noisy — there is no background noise on the Moon. At 1:54 P.M. July 21, having spent 22 hours on the lunar surface, Aldrin counted down and fired the ascent stage engine which functioned perfectly. They docked with Columbia and rejoined Collins, who had seen none of this, at 5:35 P.M. Collins touched off the Apollo main engine at 12:55 A.M. July 22 while on the Moon's dark side and Columbia headed home. The spaceship's landing site was changed due to stormy seas and the astronauts adjusted their course to the new site 270 miles away, splashing down in the Pacific at 12:50 P.M. EDT July 24. President Nixon and Dr. Paine were on the aircraft carrier to greet them.

Astronaut Michael Collins in Columbia photographed approaching Eagle following liftoff from the Moon. Earth rising above the Moon's horizon is visible in the background.



The astronauts climbed into a van which would carry them to Houston where they entered quarantine in the Lunar Receiving Laboratory as a safeguard against bringing back to Earth any possible hostile organisms. The quarantine ended August 12 with a press conference and a welcoming luncheon in the Rice Hotel attended by 600 NASA and industry members of the Apollo team — KSC's delegation numbered 50.

Ticker tape parades in New York and Chicago August 13 were climaxed by a Presidential dinner in Los Angeles that evening. Again, KSC was represented by Dr. Debus and several key members of his launch team.

These were Apollo 11's unparalleled achievements:

—first manned lunar landing and return
—first extra vehicular activity on lunar surface
—first seismometer deployed on Moon
—first laser reflector deployed on Moon
—first solar wind experiment deployed on Moon
—first lunar soil samples returned to Earth
—successful accomplishment of all mission objectives
—sixth successful Saturn V on-time launch
—largest payload ever placed in lunar orbit
—first lunar module test in total operational environment
—acquisition of numerous visual observations, photographs and television of scientific and engineering significance

The Apollo program had achieved its objective five months and ten days before the end of the decade.

President Richard M. Nixon greeted astronauts Armstrong, Aldrin and Collins aboard the U.S.S. Hornet.

APOLLO 11

MISSION SEQUENCE OF EVENTS

EVENT	*PLANNED (GET) Hr:Min:Sec	ACTUAL (GET) Hr:Min:Sec
Range Zero (09:32:00 EDT)	00:00:00	00:00:00
Earth Parking Orbit Insertion	00:11:49	00:11:49
Second S-IVB Ignition	02:44:15	02:44:16
Translunar Injection	02:50:14	02:50:13
CSM/S-IVB Separation, SLA Panel Jettison	03:15:00	03:17:--
CSM/LM Docking Complete	03:25:00	03:29:--
Spacecraft Ejection from S-IVB	04:09:45	04:17:13
Spacecraft Evasive Maneuver	04:39:45	04:40:01
S-IVB Slingshot Maneuver	05:02:03	Not Available
Midcourse Correction – 1	11:45:00	Not Performed
Midcourse Correction – 2	26:45:00	26:44:58
Midcourse Correction – 3	53:55:00	Not Performed
Midcourse Correction – 4	70:55:00	Not Performed
LOI-1 (Lunar Orbit Insertion) Ignition	75:54:28	75:49:50
LOI-2 Ignition	80:09:30	80:11:36
LM Undocking from CSM	100:13:38	100:13:38
CSM Separation Maneuver	100:39:50	100:39:50
LM Descent Orbit Insertion	101:38:48	101:36:14
Powered Descent Initiation	102:35:13	102:33:04
Lunar Landing	102:47:11	102:45:43
Plane Change Maneuver (CSM)	107:05:33	Not Performed
Crew Egress for Lunar Surface Operations	112:40:00	109:07:35
Crew Ingress	115:10:00	111:39:12
LM Liftoff	124:23:26	124:22:00
Coelliptic Sequence Initiate Maneuver	125:21:19	125:19:35
Plane Change Maneuver (LM)	125:50:28	Not Performed
Constant Differential Height Maneuver	126:19:37	126:17:46
Terminal Phase Initiate Maneuver	126:58:08	127:03:31
Terminal Phase Finalize Maneuver	127:40:38	127:45:54
CSM/LM Docking	128:00:00	128:03:--
LM Jettison	131:53:05	130:09:55
CSM Separation Maneuver	131:53:05	130:30:00
Transearth Injection (Ignition)	135:24:34	135:23:42
Midcourse Correction – 5	150:24:00	150:29:55
Midcourse Correction – 6	172:00:00	Not Performed
Midcourse Correction – 7	192:06:00	Not Performed
CM/SM Separation	194:50:00	194:49:19
Entry Interface (400,000 feet)	195:05:04	195:03:06
Landing	195:19:06	195:18:35

* Prelaunch planned times are based on MSFC Launch Vehicle Operational Trajectory and MSC Spacecraft Operational Trajectory

The astronauts addressed a joint session of Congress September 16 and then embarked upon a world tour during which they were received with acclaim traditionally reserved for heroes.

Recognition came to others who were involved in the magnificent achievement — Dr. Debus, Dr. von Braun, and Dr. Gilruth were formally installed in the National Space Hall of Fame in Houston, Texas Sept. 26. So were Astronauts John Glenn and Alan Shepard whose pace-making pioneer flights helped pave the way for Apollo 11.

The NASA Administrator, Dr. Thomas Paine, visited KSC Sept. 30 to award NASA honors to Government personnel in recognition of their Apollo achievements. Group Achievement Awards were presented to KSC and to the Air Force Eastern Test Range. Distinguished Service Awards went to Dr. Debus, General Jones, A. F. Siepert, Rocco Petrone, Raymond Clark, Dr. Hans Gruene and John J. Williams.

Exceptional Service Awards were presented to Miles Ross, John Atkins, G. L. Harris, R. F. Heiser, R. E. Johnson, John W. King, Walter P. Murphy, Thomas Goldcamp, C. A. Guthrie, Edward Mathews, Donald Buchanan, G. M. Preston, Chester Wasileski, Grady Williams, Ernest Amman, Gordon Artley, Dr. R. H. Bruns, Peter Minderman, Karl Sendler, R. O. Wilkinson, R. E. Gorman, B. E. Stimson, Frederic Miller, C. C. Parker, Charles Buckley, George Van Staden, Benjamin Hursey, William M. Lohse, Emil Bertram, Paul Donnelly, W. J. Kapryan, R. E. Moser, John Potate, William Schick, Marion Edwards, Lionel Fannin, Roy Lealman, Robert G. Long, Alfred O'Hara, Donald Oswald, Henry Paul, Andrew Pickett, Wallis Rainwater, Isom Rigell, Joseph Bobik, Clarence Chauvin, Roger Gaskins, John Janokaitis, Charles Mars, George Page, Raul Reyes, George Sasseen, Thomas Walton, Herman Widick, Col. E. P. Ballinger, Col. R. W. Hoffman, Col. S. H. Nichols, Col. R. G. Olson and Lt. Col. Rabey, U.S. Air Force, and W. P. Bass, ETR chief of plans and requirements.

NASA Public Service Awards were presented to R. F. Gompertz, L. H. Yount and P. F. Fahey, Chrysler Corp.; F. L. Coenen, J. J. Cully, W. H. Holmes, Boeing; Bastian Hello, T. J. O'Malley, A. C. Martin, North American Rockwell; S. D. Truhan, McDonnell Douglas; A. G. Belleman, IBM; G. M. Skurla, Grumman; F. A. Dasse, AC Electronics; L. D. Solid, Rocketdyne; F. W. Vaughn, Bendix; L. F. Dupuy, Catalytic-Dow; T. J. Cameron, Federal Electric; G. T. Smiley and E. F. Lowell, General Electric; H. J. Hays, Service Technology Corp.; Harry Olander and R. W. Wilson, TWA; Charles Borders, Pan Am and G. D. Clark, RCA.

APOLLO 11

POWERED FLIGHT SEQUENCE OF EVENTS

EVENT	*PLANNED (GET) Hr:Min:Sec	ACTUAL (GET) Hr:Min:Sec
Range Zero (09:32:00.0 EDT)	00:00:00.0	00:00:00.0
Liftoff Signal (TB-1)	00:00:00.6	00:00:00.6
Pitch and Roll Start	00:00:13.8	00:00:12.4
Roll Complete	00:00:31.8	00:00:31.1
S-IC Center Engine Cutoff (TB-2)	00:02:15.3	00:02:15.2
Begin Tilt Arrest	00:02:40.8	00:02:40.0
S-IC Outboard Engine Cutoff (TB-3)	00:02:41.1	00:02:41.6
S-IC/S-II Separation	00:02:41.8	00:02:42.3
S-II Ignition (Engine Start Command)	00:02:42.5	00:02:43.0
S-II Second Plane Separation	00:03:11.8	00:03:12.3
Launch Escape Tower Jettison	00:03:17.5	00:03:17.9
S-II Center Engine Cutoff	00:07:40.1	00:07:40.6
S-II Outboard Engine Cutoff (TB-4)	00:09:11.7	00:09:08.2
S-II/S-IVB Separation	00:09:12.5	00:09:09.0
S-IVB Ignition (Engine Start Command)	00:09:12.7	00:09:09.2
S-IVB Cutoff (TB-5)	00:11:39.5	00:11:39.3
Earth Parking Orbit Insertion	00:11:49.5	00:11:49.3
Begin S-IVB Restart Preparations (TB-6)	02:34:37.3	02:34:38.2
Second S-IVB Ignition	02:44:15.3	02:44:16.2
Second S-IVB Cutoff (TB-7)	02:50:04.1	02:50:03.0
Translunar Injection	02:50:14.1	02:50:13.0

*Prelaunch planned times are based on MSFC Launch Vehicle operational trajectory.

XIV

Yankee Clipper And Intrepid

As Neil Armstrong and Edwin Aldrin left the first footprints on the Moon, while Michael Collins remained at the controls of Columbia, KSC continued the checkout, assembly and test of the eighth Apollo Saturn V configuration earmarked for Apollo 12.

NASA selected a veteran space pilot, Charles "Pete" Conrad, Jr. to command the second lunar landing attempt. He had flown Gemini V with L. Gordon Cooper in an eight-day mission launched August 21, 1965. During 120 revolutions of Earth, they successfully simulated rendezvous and tested the first fuel cell system carried in a Gemini spacecraft. Next Conrad and Richard F. Gordon, Jr. flew Gemini XI for 72 hours and 17 minutes, during which they docked with an Agena orbiting stage 1 hour and 36 minutes after leaving Earth. Gordon spent 2 hours and 55 minutes outside the spacecraft in a demonstration of extra vehicular activity. He became command module pilot for Apollo 12. The third member of the crew, Alan Bean, had not previously flown in space. He would be the lunar module pilot.

Apollo crews develop personalities as the logical consequence of an unusual occupation that demands the ultimate in teamwork and rules out individual preference. What emerges is a blending of three distinct personalities who learn to think and react as if one brain directed their movements. Each crew is unique, but all crews are alike in their total dedication to the mission and their comrades.

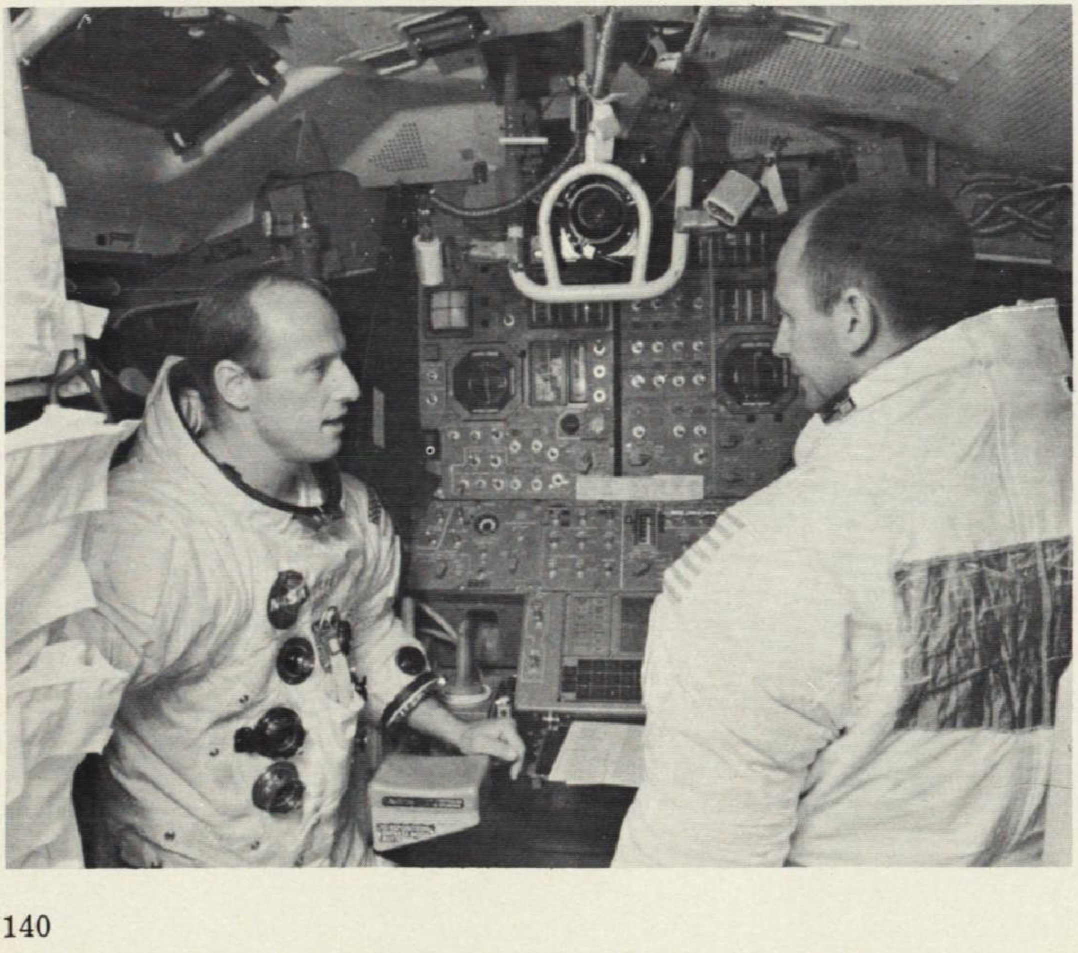
So the Apollo 12 astronauts lived, worked, and trained together for more than a year. Each devoted substantial effort in his special area of responsibility, collectively they knew the lunar module, command and service module systems at least as well as the technicians and engineers who fabricated and assembled them. As the mission was to reveal, this was a professional crew of relatively uninhibited character — they disclosed their feelings as frankly as any U.S. astronauts who ever flew in

space. To the utter delight of the public and press, they said what was on their minds on the ground, en route to and from the Moon, and on the lunar surface.

The crew took up residence at KSC in mid-August for the final pre-flight training. In early October they flew to Flagstaff, Arizona for a short stay to rehearse moon walk procedures in terrain which resembles that anticipated in the Ocean of Storms region of the Moon, their targeted landing point.

For several months prior to their arrival, however, the launch organization had worked on the vehicle and spacecraft. The first of the AS-507 stages arrived March 9, six days after the Apollo IX launch. Ascent and descent stages of Intrepid, as the all-Navy crew dubbed the lunar module, came in later that month. So did the command and service modules, named Yankee Clipper. By early May, the Saturn V power stages and instrument unit were well along in receiving inspection and checkout. The prime and backup crews tested the spacecraft in altitude

Apollo 12 Commander Charles Conrad and Lunar Module Pilot Alan Bean underwent hundreds of hours of training in this lunar module simulator at KSC prior to launch.



chambers without incident. Clipper and Intrepid were transferred to the Vehicle Assembly Building June 30 and mated with Saturn V.

From that point on, much of the testing involved the integrated systems of the launch vehicle and spacecraft. The painstaking care with which the sequential tests are conducted reflected the determination of the launch team to assure good performance throughout the 953,000-mile journey to and from the Moon. When abnormal conditions were detected in the constant monitoring, repairs or replacements were taken care of without impacting the schedule. On the eve of the Apollo 11 launch, Intrepid's test team verified the lunar module sub systems. Another group tested the command and service modules, changing out fuel cells in Apollo. A suspected component in the Saturn V instrument unit was removed for special testing in New York and returned a week later. Technicians drained water glycol from Intrepid and thoroughly cleansed the system. A rate gyroscope in the lunar module guidance computer was re-examined by Grumman at Bethpage, L. I., verified and returned.

With September came a major change in management as Dr. Rocco Petrone left the launch director's post to become Apollo Program Director in NASA Headquarters. His deputy, Walter J. Kapryan, succeeded him and the launch preparations moved ahead without interruption. Apollo 12 rolled out of the Vehicle Assembly Building aboard its mobile launcher at daylight September 8. Launcher and space vehicle were firmly secured on the firing site by 1:30 P.M. the same day. The mobile service structure was transferred to the pad two days later. Its work platforms enabled the spacecraft team to complete servicing Apollo.

By September 25, Yankee Clipper had passed flight readiness tests. Astronauts and the pad rescue team participated in emergency egress rehearsals. By the end of September, the space vehicle's mechanical, electrical and electronic systems had been tested for flight and the launch team prepared for fueling.

Even at this point in the preparations, more corrective tasts had to be performed. The Manned Spacecraft Center requested x-rays of Intrepid's water tanks. They were found satisfactory. Several relays had to be replaced in the Saturn V instrument unit. The full-scale dress rehearsal for launch, the countdown demonstration test, began at T minus 113 hours October 22. Propellants and oxidizer were pumped into the huge tanks of the launch vehicle and the tanks of the spacecraft. While the test proceeded, several relay modules in the second and third vehicle stages were changed and retested. Ordnance was installed in Apollo. The CDDT concluded October 28. Next day the flight crew participated in a "dry" version after the hazardous propellants had been drained from the Saturn tanks.

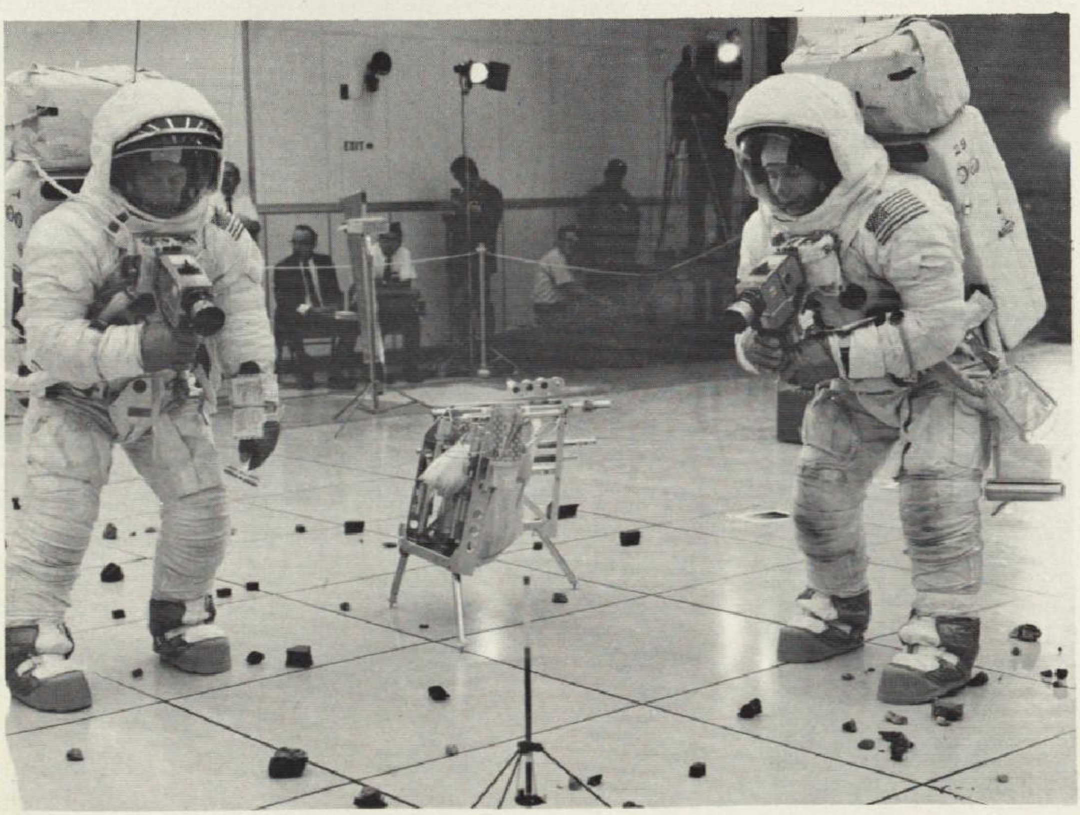
A liquid oxygen replenishment pump failed during the fueling and was speedily repaired. A broken circuit breaker tip was replaced in the

lunar module. The new color television equipment developed for use on the lunar surface had given some problems, but it passed a re-test November 6 and was accepted for flight.

Directing the launch preparations for Kennedy were James Harrington, test supervisor; Ray Roberts, launch vehicle test conductor; C. A. Chauvin, command and service module test conductor; and Fritz Widick, test conductor for the lunar module. Joe Barfus managed test support and Robert McQuarry functioned as support controller. Each had a counterpart conductor, representing the contractor organization responsible either for the vehicle, spacecraft or launch support. The 450 NASA and industry engineers, technicians and managers occupying Firing Room 2 included Dr. Debus, the Center Director; Launch Director Kapryan; Dr. Hans Gruene, Saturn V operations director; J. J. Williams, spacecraft operations director; I. A. Rigell, launch vehicle chief engineer; Andrew J. Pickett, test operations manager; Ray Clark, technical support director and Paul Donnelly, test operations chief.

Countdown for launch commenced at 8 A.M. November 7 and the

Commander Charles Conrad and Lunar Module Pilot Alan Bean use cameras as they simulate photographic documentation of rock samples on the surface of the Moon during preparation for the Apollo 12 mission.



clock started at T minus 108 hours. Four holds were built into the count to allow time for solving problems that might occur or to permit the launch team to rest. Five miles south, in the Spaceport's industrial area, the crew spent hours daily in the simulators rehearsing every detail of the mission. NASA's worldwide tracking network, operated by the Goddard Space Flight Center, tested vital communications links. Aircraft and ships took up assigned stations in anticipation of launch. The astronauts passed their final physical check with flying colors November 10.

A problem developed at T-40 hours. One of the two hydrogen tanks in Clipper's service module failed to chill down when the extremely cold liquid propellant was pumped aboard. Tanking continued until both tanks were 90 per cent full. The quantity in No. 2 tank continued to drop off, and frost could be seen on the outer shell. This was interpreted to indicate either that the inner shell was leaking, allowing hydrogen to flow between the shells, or that a leak had occurred in the outer shell. Spacecraft Director John Williams conferred with Manned Spacecraft Center officials. They decided to remove the suspect tank and replace it with a tank from Apollo 13. Technicians worked around the clock to make the substitution and the countdown proceeded. At T-24 hours the crew pulled off a surprise. They flew their T-38 jets across KSC as a salute to the launch team.

Tom Stafford, who became Chief of the Astronaut Office at MSC following Alan Shepard's return to flight status, awakened the astronauts early November 14. Jim Irvin, James McDivitt, Paul Weitz and Chuck Tringali breakfasted with the crew. A sixth guest was a stuffed gorilla, togged out in flight suit and crash helmet, the gift of a friend to Commander Conrad. The crew then donned pressure suits, departed the Manned Spacecraft Operations building at 8:10 A.M. and entered Apollo 12 at the 310-foot level of the space vehicle. The hatch was closed 1 hour and 44 minutes before launch.

The weather turned unpleasant during the night. Rain fell intermittently. Dark clouds moved northeasterly across the launch site. Launch Director Kapryan kept in close touch with the KSC ESSA weather station whose readings were supplemented by two aircraft flying through and just above the cloud cover over the Spaceport. They reassured him there was no lightning. Heavy rains occurred in the hour before ignition. President and Mrs. Nixon arrived at T-40 minutes, joining 4,000 other observers at the site north of the Vehicle Assembly Building. The ceiling above the pad was measured at 1,000 feet, or twice the required minimum. Precisely on schedule, Apollo 12 lifted from the pad at 11:22 A.M. Eastern Standard Time.

The giant rocket disappeared into the clouds. At the 36-second mark, the startled crowd at the viewing site saw two flashes of lightning streak

groundward on either side of the launch tower. Conrad reported: "We just lost the platform. I don't know what happened here. We had everything in the world drop out — fuel cell, lights, AC bus light, fuel cell disconnect, AC bus overload, one and two main bus A and B out . . ."

Saturn V never faltered. Launch Director Kapryan later compared the power outage to a fuze blowout in a home and said it protected vital electronic instrumentation. The crew reestablished the inertial platform and soon had power flowing in all systems. Since this was the first such occurrence in the history of the space program, it was intensively studied by the Kennedy, Marshall and Manned Spacecraft Centers. It has been theorized that the 363-foot vehicle, plus its long flaming tail, became a lightning rod which triggered static electricity in the cloud cover. As a result of the studies, additional instrumentation is employed in the prelaunch period, airborne as well as ground sites, and it is unlikely a Saturn launch would occur again under similar conditions.

After this unnerving incident, the mission became a textbook flight. Apollo 12 was inserted into Earth orbit 11 minutes and 43 seconds after liftoff. At 2:15 P.M., the Yankee Clipper and Intrepid had accelerated to 24,000 miles an hour and headed for the Moon. There was a significant departure in the transearth trajectory. Three earlier Apollos flew a course which permitted looping the Moon and returning to Earth if the spacecraft failed to attain lunar orbit. Apollo 12, by a midcourse maneuver, entered a trajectory that did not allow free return. This was necessary to reach the desired landing site.

At 00.45 minutes November 19, by Earth time, Intrepid began the looping orbit which would carry the crew down to the Ocean of Storms. As they approached, Earth heard this conversation:

Bean: 35 degrees, 530 feet, Pete, 530, 471 all right 426.

Conrad: I got it.

Bean: 400. You're at 366 Pete.

Conrad: Right.

Bean: You're at 330 feet coming down at 4. Eleven per cent. Got loads of gas. 300 feet coming down at 5.

Conrad: Oh, look at that crater, right where it is supposed to be. You're beautiful.

Bean: 10 per cent. 257 feet coming down at 5. 240 coming down at 5. Hey, you are really maneuvering around!

Conrad: Yeah.

Bean: Come on down, Pete. 10 per cent fuel. 200 feet coming down at 3. You can come on down, 180 feet, 9 per cent, you're looking good. Gonna get some dust before long. 30, 124 feet, Pete. 120 feet, coming down in 6. Got 9 per cent, 8 per cent. You're looking OK. Slow down the descent rate. You're looking good. 70 feet, looking real good. 50 feet,

coming down, watch for the dust. 42 feet. Coming down in 3. Coming down in 2, OK. Start the clock. Looking good, watch the dust. 32, 31, 30 feet, coming down in 2. Pete you got plenty of gas, plenty of gas, babe. Stay in there.

CAPCOM: 30 seconds.

Bean: 18 feet, coming down in 2. He's got it made. Come on in there. 24 feet. Contact light!

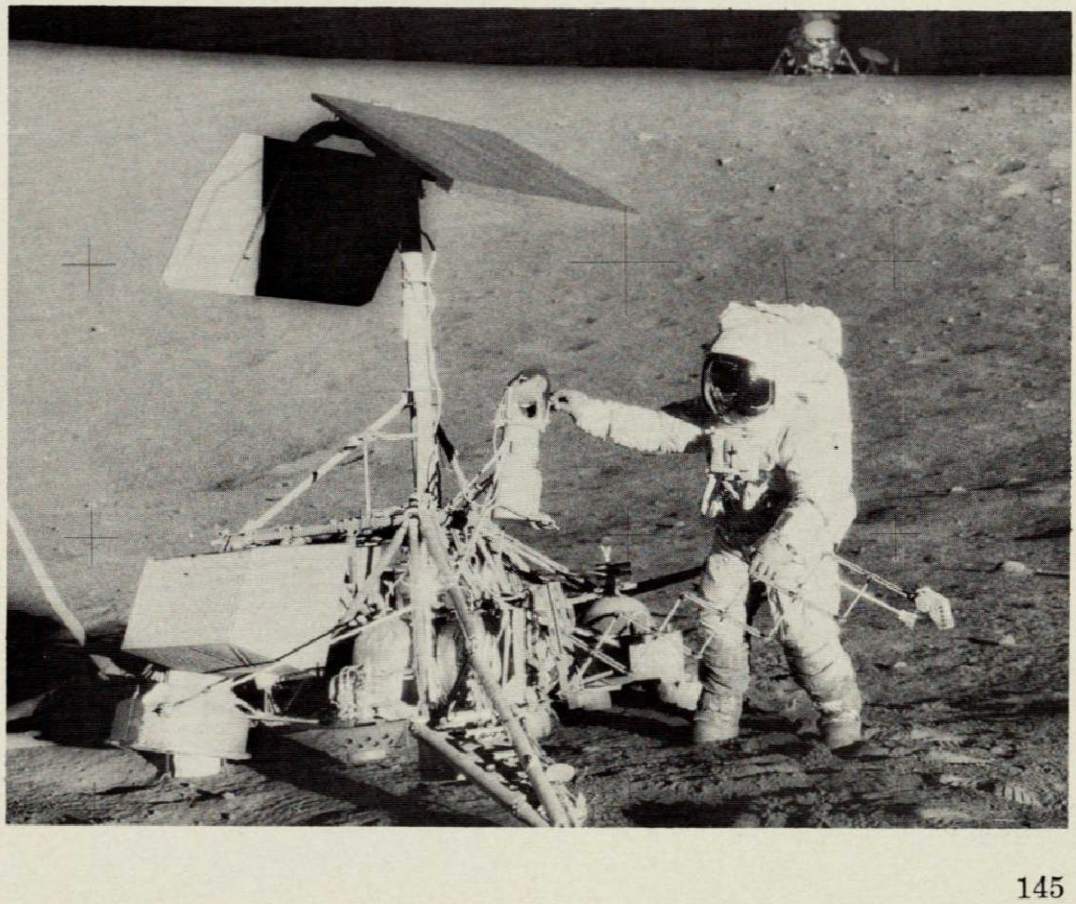
Conrad: Okey, dokey. I cycled the main shut off valve.

Intrepid landed at 1:54:35 A.M. Eastern Standard Time November 29. After five hours of work and rest period, Conrad climbed down the ladder with this comment:

Conrad: "They aren't kidding when they say things get dusty, whew! I'm headed down the ladder. Man, is that a pretty looking sight, that LM."

As his foot made contact with the surface, Pete ejaculated: "Whoopie! Man, that may have been a small one for Neil, but that's a long one for me . . . Boy, you'll never believe it, guess what I see sitting on the side of the crater, the old Surveyor." He and Bean laughed. They

Lunar Module Pilot Alan Bean inspects Surveyor III television camera. Intrepid, visible in background, touched down 600 feet from Surveyor.



had touched down within 600 feet of Surveyor III which landed on the Moon two years before. In all, the two astronauts spent 7 hours and 45 minutes working on the Moon, setting up scientific instruments, collecting pieces from the Surveyor, collecting lunar materials and photographing their landing craft, the Surveyor and other objects of interest. One mishap occurred — the color TV camera malfunctioned when inadvertently exposed to the direct sunlight. Consequently, Earth did not see the explorers while they worked, but their verbal account came through beautifully.

Conrad's skill as a pilot demonstrated the possibility of precise navigation in lunar flights. He monitored the Intrepid computer to compensate for errors that would have carried the lunar module five miles north of the target area.

Seventy-five pounds of lunar material were collected, some quite different from the materials returned by the Apollo 11 expedition. Chemical analysis revealed traces of potassium, uranium and thorium in greater abundance with less titanium content than the materials picked up in the Sea of Tranquility. Most noteworthy, however, was the apparent age of the material — it was estimated to be a billion years younger. The crew deployed a nuclear power package which energizes the seismometer, magnetometer, lunar atmosphere detector and ionosphere detector implanted on the Moon which transmit scientific data to Earth receiving stations. Dust hampered the surface activity and seriously impaired the quality of photography. Overall, however, Conrad and Bean did a highly useful job in gathering information and samples which have excited the scientific community and built up demands for more manned flights to the Moon.

Conrad and Bean lifted off in the Intrepid ascent stage at 9:25 A.M. November 20. Dick Gordon skillfully piloted the Clipper to a successful docking at 12:58 P.M. Intrepid was then jettisoned to impact on the Moon at a velocity of about 5,000 miles per hour. Impact occurred about 45 miles from the landing site of Intrepid and set off shock waves registered on the seismometer for 55 minutes. This intrigued scientists for a similar impact on Earth would register only about two minutes.

En route home, the astronauts conducted a press conference in Yankee Clipper by responding to questions from newsmen in Mission Control. They later reported the return trip was actually boring and suggested the need for reading material or music during subsequent three-day journeys. Clipper reentered Earth's atmosphere at 3:44 P.M. November 24 and splashdown followed at 3:58 P.M. in the South Pacific. Apollo 12 concluded a successful mission at 244 hours, 36 minutes and 25 seconds after liftoff from Pad A at Launch Complex 39.

During quarantine at the Manned Spacecraft Center, plans were formulated for a world tour but the crew insisted the first visit would

be to KSC for reunion with the launch team. So they came back December 17. Dr. Debus led them into the Transfer Aisle of the Vehicle Assembly Building as a Navy band played "Anchors Aweigh" and 8,000 members of the Government-industry team applauded the crew. Dr. Debus recalled that at lunch with the crew just before their epochal flight, Pete Conrad told him they would return. He noted they left as U.S. Navy Commanders and returned as U.S. Navy Captains.

"The crew didn't consider the flight over until we got back here," Conrad remarked. "We forgive the weather man for his job, but had we to do again, I'd launch exactly under the same conditions. We had such fine equipment that when you add up the little difficulties we came up with on the flight, it wouldn't fill a half page of paper. People have said I was punchy out there on the Moon and had too much oxygen, but that's not the case. After landing next to Surveyor and realizing that we were going to get all the work done, and it turned out it was very easy, I was just so happy about the way things were going, I got happier the longer we were out there."

Apollo 13 Commander Charles Conrad in foreground is greeted by an acquaintance following a ceremony in the Vehicle Assembly Building December 17, 1969 during which the crew thanked the launch team for its role in the successful mission. Lunar Module Pilot Alan Bean in background signs an autograph and Command Module Pilot Richard Gordon reaches to shake hands with a launch team member.

He observed that the crew was proud to have opened the door to scientific exploration on the Moon — then he added, "I'd just like to tell you, you all did a hell of a job for us."

Dick Gordon pointed out that "the real guts of these flights, after their formative, opening stages, are really put together here. The hardware is brought here, it's mated here in the VAB, and a great amount of testing is done. But more importantly, the crew is here most of the months before launch. And this is really the way it ought to be. This is really our home."

Alan Bean expressed the crew's appreciation to the people who built their rocket and spacecraft and the KSC team who made sure they would function when and as required. "The lunar mission to me," he added, "was a fantastic adventure and it brought a lot of thoughts about space and many things. But one of the things it brought home is how much we, the three of us, depended on you people, and the three in Apollo 13 and those in 14 and 15. If you care as much about your hardware, and it looks like you do, I think your success is going to be just as great as it has been in the past."

The astronauts received enlarged color photographs of the Apollo 12 liftoff from Dr. Debus, plus a stone from the Crawlerway over which their vehicle began its journey. Then they walked through cheering crowds along the Transfer Aisle, exchanging handshakes and signing autographs. They lunched with Dr. Debus, the KSC Management Council and contractor managers where they regaled the party with some lighthearted comments about their achievement. KSC presented them with such trinkets as whisk brooms to remove lunar dust, tiny parasols to ward off the intense sunlight on the Moon, and joke books to while away long hours on lunar journeys. All in all, it was a happy family reunion.

Later the astronauts were feted in Washington, and at the Tournament of Roses, and embarked on a world tour February 15, 1970, escorted by Joe Jones, MSFC's news director, which concluded March 26. They were heralded as modern Jasons in Venezuela, Chile, Peru, Panama, the Canary Islands, Portugal, Luxembourg, Finland, Romania, Denmark, Austria, Morocco, Algeria, the Ivory Coast, Tanzania, Malagasy, Ceylon, Burma, Indonesia, Formosa and Japan.

Of their flight, Dr. Debus commented: "Besides the valuable and unique materials, they brought back something else. As the world held its breath during the mission, and was entertained in the best tradition by the unbeatable humor and wit of the Apollo 12 crew, the world again felt as a single family, a family whose members were out there in a menacing and unforgiving area, doing things for all of mankind. They were there as sentinels for all the people of a seemingly very lonely world. Perhaps we came a step closer to recognizing that in cooperative space endeavors may eventually be found the key to a lasting peace."

XV

Lifeboat in Space

SHORTLY after 10 P.M. Eastern time, April 13, 1970, radio and television bulletins reported a problem in the Apollo 13 spacecraft speeding toward the Moon at 3,265 feet per second and 177,900 nautical miles from Earth.

Earlier the crew demonstrated the ease with which they could move about Odyssey and Aquarius in a color television report. When the scheduled broadcast ended, a routine conversation followed between Mission Control and the astronauts. They were instructed to roll the spacecraft in order to photograph Comet Bennett, terminate a battery charge, check thrusters, and stir up the cryogenic tanks containing liquid oxygen in the service module. The crew acknowledged, but suddenly the tone changed:

"Okay, Houston. Hey, we've got a problem here!"

The proportions of the dilemma became apparent from the crew's rapid-fire descriptions:

"We've had a problem. We've had a main B bus interval. And we had a pretty large bang associated with the caution and warning. We're starting to button up the tunnel (between the spacecraft). We had a restart on our computer. Fuel cells 1 and 2 are both showing gray flags. Number 2 cryo tank is reading zero. We are venting something into space . . ."

As the crew accurately reported their instrument readings, Mission Control, NASA and the free world understood that the unspoken dread of emergency in space had almost instantly become real. Not since Gemini VIII forced Neil Armstrong and David Scott to an emergency landing in the Pacific from Earth orbit had the agency confronted this situation. It did not require an engineer's appraisal for any man to recognize this was shaping up as a monumental tragedy — Apollo 13 was committed, no "free return" could automatically ensue, there was

no possibility of rescue, and second by second the momentum of their spacecraft carried them farther from Earth.

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Two manned lunar landings in 1969 more than met the objective laid down by the late President Kennedy in 1961 and thereafter supported by President Johnson, President Nixon and succeeding Congresses. NASA accomplished the seemingly impossible task of placing four Americans on the Moon and returning them safely to Earth.

As the agency moved into 1970, the outlook was for fewer Apollo launches prepared by 6,000 fewer people at the Kennedy Space Center. It was no longer necessary to launch to the Moon on two months' centers. Now the lunar exploration program could move forward at more leisurely pace as the scientific community desired. Two launches per year instead of five were to allow time between visits to evaluate the findings of each and revalidate requirements for the next. The first such mission would be Apollo 13 flown by James Lovell as commander, Thomas Mattingly as command module pilot and Fred Haise as lunar module pilot.

Lovell was the veteran, his crewmates would make their debut in space. Lovell's experience included Gemini VII, the 14-day mission flown with Frank Borman from December 4 to December 17, 1965; Gemini XII, last of the program, with Edwin E. Aldrin from November 11 until November 15, 1966; and the immortal Apollo 8 journey to the Moon with Borman and William A. Anders, December 21-December 27, 1968. He had more hours in space than any other human.

The Kennedy Space Center undertook preparations for this launch in June and July 1969 as the launch vehicle stages arrived. Command and service modules were delivered by Super Guppy aircraft June 26, while the lunar module stages arrived the next two days. The astronauts named them Odyssey and Aquarius — a name that would be remembered best as a lifeboat in space. The target was Fra Mauro, a hilly area of the Moon of major interest to science.

The NASA-industry team undertook searching examination of stages and spacecraft while Apollo 11 captured headlines and other launch experts continued the checkout, assembly and test of Apollo 12. During July 1969, the spacecraft were powered up for combined systems testing. Docking and leak test of Odyssey with the Aquarius ascent stage followed. Prime and backup crews completed simulated altitude runs in the command module in August. Next month both crews participated in simulated chamber runs of Aquarius followed by the actual altitude runs in the Manned Spacecraft Operations building.

As the rigorous testing disclosed problems, they were corrected. Altitude chamber testing revealed leaks in gaseous oxygen shutoff valves in the lunar module. They were replaced. X-ray examination of diffuser welds resulted in a decision to changeout the items. Odyssey's forward

heat shield needed attention. This was repaired in early October. Rendezvous radar of both spacecraft were tested for compatibility as positive assurance that they would function properly in space.

Technicians replaced a water glycol line in the lunar module, then mated the ascent and descent stages. A fuse module connected to Odyssey's mission event sequence controller had to be changed. A newly developed color television camera designed for Aquarius failed in October and was returned to the manufacturer. After modification, the camera was retested in early November and found satisfactory. Next, the VHF antenna had to be changed and retested.

Two days before the November 14 launch of Apollo 12, a hydrogen tank in the service module acted up. One tank was removed from Odyssey and installed in Yankee Clipper on the launch pad as the suspect tank was taken out. A replacement tank was installed in Odyssey. Then a transducer misbehaved in the descent stage engine of Aquarius. It was changed and retested. The spacecraft were transferred to the Vehicle Assembly Building and erected on the Saturn V vehicle December 11. The launch escape system was placed atop Apollo, then the crawler moved mobile launcher and space vehicle to Pad A at Complex 39 December 15.

Both spacecraft were powered up for integrated systems tests. Meanwhile, having reviewed the schedule in the context of the FY 1970 budget, NASA decided on January 9 to postpone the launch from March until April.

The close scrutiny of systems and sub-systems continued. Voltage fluctuations and low output from Fuel Cell 1 in the service module prompted a decision to replace the cell. A new altimeter and a new digital event timer were installed in Odyssey, and the electrical interface test between the two spacecraft was completed January 13. Propulsion system fuel and oxidizer helium modules were removed and reworked by Grumman at Bethpage, L.I., and reinstalled February 5. Mission simulations with Aquarius were completed February 24. Two fuel cells were returned to the manufacturer for glycol dryout and replacement of a pump. They were returned in March. Propellant leak and functional tests of the spacecraft were conducted, and ordnance was installed March 16.

Operating under supervision of senior KSC management the launch team prepared for the countdown demonstration test. Norman M. Carlson was chief test conductor; Jack E. Baltar and John R. Copeland, Saturn V test conductors; Bert L. Grenville, space vehicle test supervisor; Arthur E. Franklin, test supervisor; Paul C. Donnelly, launch operations manager; Robert E. Moser, test planner; Lynn E. Henshaw, Boeing test engineer; Ralph D. Carothers, spacecraft manager; Gene R. Nurnberg, North American spacecraft chief; Mark J. Goodkind, Grumman assistant

spacecraft test manager and Stephen Wakely, lunar module test manager. Gordon E. Artley and Joseph N. Barfus coordinated test support.

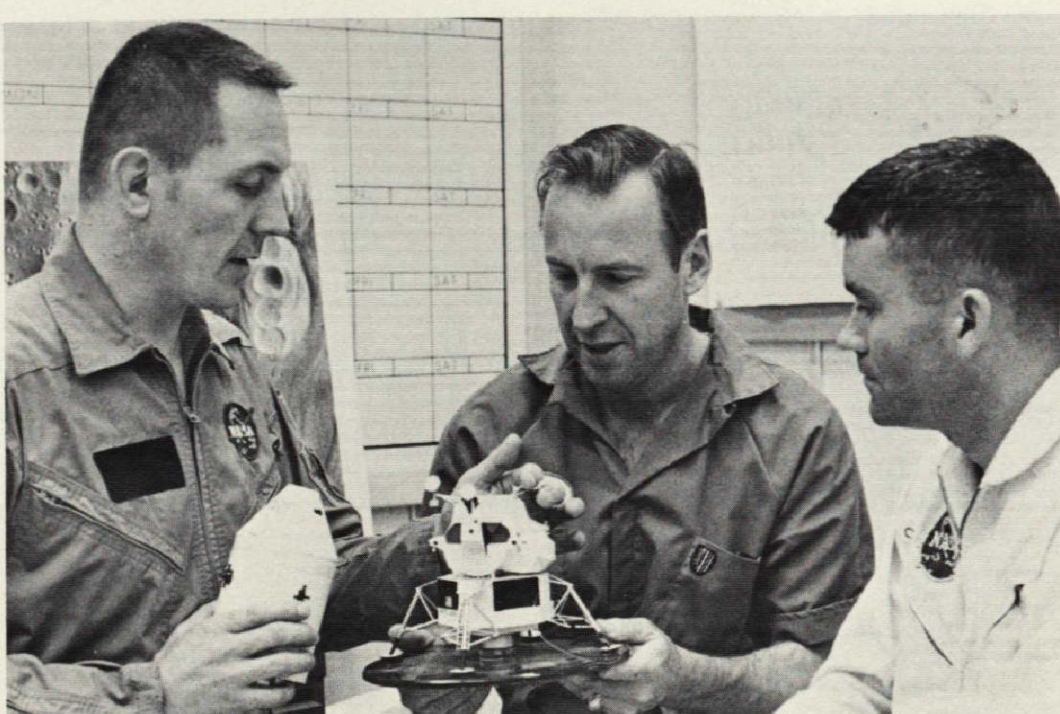
The fueled space vehicle was successfully counted down in the major pre-launch test from March 18 through March 25. Hazardous propellants were pumped out of the Saturn V tanks next day for the "dry" phase of the test in which the flight crew participated for five hours. Apollo 13 was ready.

Launch Director Walter J. Kapryan started the final countdown April 5. Next day Lovell, Mattingly and Haise passed the physical checkup which precedes every Apollo mission. They spent the rest of that day rehearsing launch abort procedures.

A totally unexpected problem developed overnight. Astronaut Charles Duke, member of the backup crew, became ill with German measles or rubella. John Young and John Swigert, who trained with him, had been exposed to possible contagion. So had the prime crew. Physicians took blood samples immediately to determine the antibody level by laboratory testing in Houston and Atlanta, Georgia. The tests were repeated April 9.

As public attention focused on the measles, amid press speculation that this might delay the mission, preparations continued at Complex 39. Liquid oxygen and liquid hydrogen loading of the spacecraft began. Dr. Charles Berry, the chief physician, announced that Lovell and Haise

Command Module Pilot John Swigert, Commander James Lovell and Lunar Module Pilot Fred Haise photographed in the Astronaut Training Facility prior to the Apollo 13 launch.



showed immunity to rubella, but Mattingly did not. Swigert, the backup command module pilot, joined Lovell and Haise in the simulators to determine his ability to conduct time critical maneuvers for the Apollo 13 flight. NASA had never substituted a pilot in like circumstances. Swigert had spent 400 hours in training, but had only 10 hours to train with Lovell and Haise.

NASA's Administrator, Dr. Thomas O. Paine, flew in from Washington to review the situation with the physicians, Deke Slayton, flight crew director; Dale Myers, manned space flight chief; Dr. Rocco Petrone, Apollo program director; Chester Lee, mission director and Julian Scheer, public affairs director. Dr. Paine talked with each of the astronauts. They reviewed the alternatives. Delay might prove costly not only in the doubled costs of preparations at Kennedy, at Mission Control, the worldwide tracking network, and the recovery fleet already on station, but in terms of the flight stages since a postponement meant at least 30 days or more exposure to corrosive effects of chemicals in both vehicle and spacecraft.

Having assured himself that the crew was prepared, Dr. Paine in mid-afternoon April 10 told press and nation that he decided to go ahead. Swigert would replace Mattingly because it woud be unwise to risk the possibility that the command module pilot might develop measles during the 10-day mission and particularly when he would pilot Odyssey alone around the Moon while his crewmates worked on the lunar surface.

The launch crew began a nine-hour rest period at 7 P.M. that evening, resuming the terminal count at 4:13 A.M. April 11 which turned out to be bright and hot. Vice President Spiro Agnew arrived with the German Chancellor, Willy Brandt, to witness the launch. Among the 5,000 invited guests were Secretary of State William P. Rogers, Secretary of Agriculture Clifford Hardin, Secretary of Housing and Urban Development George W. Romney, Secretary of Labor George P. Schultz, Secretary of the Navy John H. Chaffee; Donald E. John, Chief of the Veterans Administration; Dean Burch, Chairman, Federal Communications Commission; Secor Browne, Chairman of the Civil Aeronautics Board; Dr. Henry Kissinger, advisor to President Nixon; the Governor of Wisconsin, Warren P. Knowles; members of the Congress, and other notables. In the 1,000-man press corps at the launch site were more than 100 West German newsmen.

The astronauts left their building shortly before noon, rode to Pad A in their van, ascended the mobile launcher elevator to spacecraft level, and entered Odyssey. The countdown was virtually trouble free until T minus 1 hour, 50 minutes when a vent valve in the first stage oxygen tank failed to close. Had it remained open, the tank could not have been pressurized as required at T minus 72 seconds. Nitrogen gas fed into the system raised the temperature sufficiently to permit closing the valve and the count proceeded.

Liftoff occurred on schedule at 2:13.06 P.M. Observers noted that the vehicle appeared to move slowly. Apollo 13 was the heaviest space ship launched to date and weighed 13 tons more than Apollo 12. The first stage operated as planned. Second stage performance was also nominal until the inboard engine shut down two minutes early. The remaining four engines compensated for the loss, burned to fuel depletion, and made up most of the energy. The third stage burned 30 seconds longer than planned so that at insertion into Earth orbit, the vehicle was traveling at required velocity in the proper flight path.

Two hours, 35 minutes and 46 seconds after liftoff, the astronauts again ignited the third stage engine which burned six minutes and increased velocity to 24,000 miles per hour, the speed required to reach the Moon. Swigert skillfully pulled Odyssey away from the stage, docked with Aquarius and extracted the lunar module from the third stage. Then the stage was guided into a trajectory which caused it to impact the Moon after 77 hours flight, touching off a reaction measured by the Apollo 12 seismometer for two hours. From this phenomenon, science gained more knowledge about the Moon and its physical characteristics.

For the next 53 hours, as Captain Lovell subsequently reported, the flight was entirely nominal. Thirty hours from Earth, the spacecraft was guided into a trajectory to carry it within eight miles of the lunar surface. The plan called for entry into Aquarius at 58 hours. Since things were going so well, the crew requested permission to proceed about three hours ahead of schedule and Mission Control quickly agreed. A television program followed, lasting about 30 minutes. As it ended, Fred Haise was in the lunar module, Swigert in the left hand seat of Odyssey and Lovell in the lower equipment bay gathering up wiring connected to the television camera.

All three astronauts heard a bang. Swigert felt the spacecraft vibrate. Within two seconds, the master alarm sounded. Haise by now had reentered Odyssey and since Swigert feared possible loss of pressure, he began to re-install the hatch to close the tunnel leading into Aquarius. Pressure was rapidly lost in the service module's No. 2 oxygen tank. Fuel cells 1 and 3 dropped to zero. Pressure decayed in No. 1 oxygen tank, forcing immediate decision to power up Aquarius, power down Odyssey and depend upon the lunar module systems for life support.

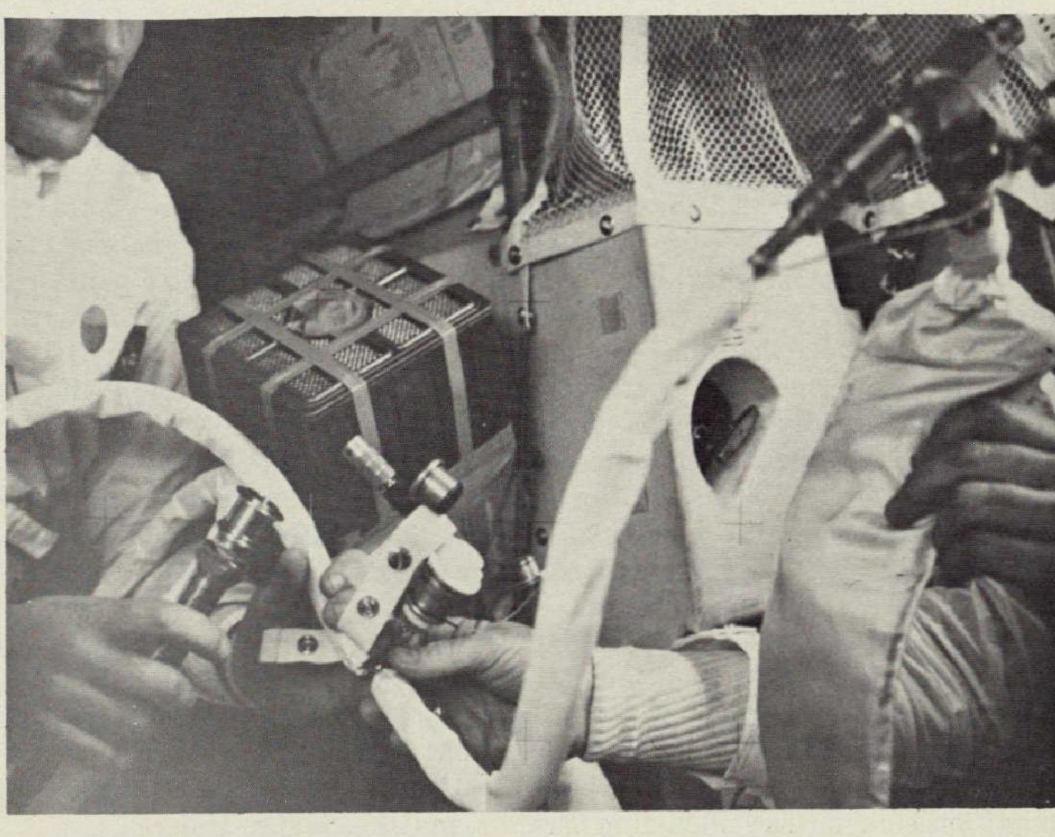
For the next 87 hours, people in many lands waited in suspense while the astronauts calmly kept up their exchanges with Earth, receiving new instructions, discussing them quietly, reporting conditions aboard the spacecraft to ground controllers who, backed up with data fed in from KSC, from the tracking stations and manufacturers, investigated alternate solutions to a series of grave contingencies. There was sharp concern about oxygen supply, without which the crew could not survive; about the supply of water, about a buildup within the Odyssey of dangerous carbon dioxide, about the capabilities of Aquarius propul-

sion system to meet the unexpected demands it must satisfy. Temperature within the cabin dropped to below 40 degrees.

Within minutes after the emergency developed, the KSC mission monitoring team and the Grumman and North American personnel at the Space Center established continuing telephone liaison with the Manned Spacecraft Center officials working the problems as they occurred. Charles Mars, lunar module project engineer, headed the group which devised the means of feeding lunar module electrical power into Odyssey when required to charge the reentry batteries. Asked how the crew might further conserve power supply, the KSC experts who had lived with the spacecraft eight months advised MSC to turn off radar heaters. They helped find the way to feed water from the portable life support systems designed for activity on the Moon into the lunar module water coolant system. They devised a method of returning water from Odyssey into Aquarius if required.

Increasing carbon dioxide threatened the crew, all three riding in Aquarius, and KSC personnel rigged a mockup system to flow air through a hose in Aquarius into lithium hydroxide containers in Odyssey. The

When the carbon dioxide level rose in the lunar module, the Apollo 13 astronauts rigged hoses to use command module lithium hydroxide to scrub the lunar module atmosphere. Command Module Pilot John Swigert prepares to connect the hoses.



astronauts did just that and the dioxide content quickly dropped to tolerable levels. Meanwhile, other Government and contractor engineers at KSC monitored performance data of both spacecraft to make sure nothing was overlooked. Riley McCafferty, who directs activities in the astronaut training at KSC, roused the Government and contractor personnel who conduct these programs and for the next several days, with other astronauts, alternate procedures were tested in the Apollo and lunar module simulators at Kennedy, Houston and Downey, Calif. Astronaut Dick Gordon sped from his Cocoa Beach motel as soon as he heard of the difficulty and began the simulator workouts at KSC. Harold Collins, in charge of the astronaut quarters, turned out his staff to support this rescue rehearsal schedule.

Mission Control maintained the same outward confidence despite the mounting tension. Six hours after the explosion destroyed the oxygen supply in the service module, the ground directed the crew to fire their descent engine. This maneuver returned the spacecraft to a trajectory which would bring them back to Earth possibly in the South Atlantic, but those close to the situation realized that the long way home — which might be the only way — would run dangerously close to exhaustion of life support systems.

Aquarius and Odyssey, linked together longer now than any lunar and command modules on other Apollo missions, flew past the Moon at a distance of about 150 miles. Two hours afterward, the descent engine was again ignited successfully and produced sufficient velocity to return the astronauts some 30 hours faster and in the South Pacific target area which had been the original destination. Two slight midcourse corrections were accomplished, one at 105 hours and another at 137 hours, to further refine the reentry trajectory.

On April 17, 138 hours, 2 minutes and 6 seconds after liftoff, the crew jettisoned the service module and maneuvered their spacecraft to observe and photograph its condition. They saw that an entire panel had been ripped off by the explosion. They said a fond goodbye to Aquarius as they jettisoned the lunar module two and one-half hours later. It had faithfully performed under conditions never anticipated by the men who built and prepared it or those who flew it. Odyssey reentered the atmosphere 142 hours, 40 minutes and 47 seconds after the flight began so auspiciously and splashed down at 1:08 P.M. Eastern time three and a half miles from the USS Iwo Jima. Man's ingenuity and the space machines he built combined to achieve the near-miraculous safe return of the crew.

Next day President Nixon greeted them in Honolulu, bringing with him to Hawaii Mrs. Lovell and Mrs. Haise, and Dr. and Mrs. Swigert, parents of the bachelor astronaut. The President decorated the astronauts and told them he had officially ruled their flight a total success, because it united the nation and brought sympathetic offers of assistance from many other countries including France and the Soviet Union.

Dr. Paine ordered a Board of Review, chaired by Edward Cortright, Director of NASA's Langley Research Center, to look into the causes of the mishap and recommend corrective actions. Searching inquiry was conducted by a group of NASA personnel from the Manned Spacecraft Center, Kennedy and other field activities under supervision of James McDivitt, who flew Apollo 9, and who now manages the Apollo program activities for MSC. Odyssey was flown back to Downey, California where the spacecraft was fabricated, for examination.

At their request, the Apollo 13 crew returned to KSC May 4 to speak to the launch team. Acting Center Director Miles Ross welcomed them in the Vehicle Assembly Building where 7,000 Government and contractor personnel gathered to salute the astronauts. Mr. Ross emphasized the magnificent teamwork demonstrated in the emergency and the offers of help from many nations.

"It's the teamwork of many people, from different walks of life, from different companies to do a job," Captain Lovell responded. "That's what we did. We're proud to come back today and tell you 'thank you.' I think the mission matured the space program a little because people were perhaps getting a bit complacent about what we do."

Jack Swigert noted the progress made in space since the Mercury era, and pointed out that "we were able to come out of a completely unrehearsed, unplanned emergency in deep space." Fred Haise said the crew fully appreciated the fact that there were many people behind their spacecraft who designed, manufactured, installed, and tested it. "We thank you at KSC for doing an excellent job," he concluded. "I'll be just as eager and optimistic to leap off in any kind of machinery that you prepare for me."

The crew presented KSC with an arm rest which they removed from Aquarius before jettisoning the module as a permanent token of their appreciation. In return, Launch Director Kapryan gave each astronaut a framed photograph of the liftoff of Apollo 13 three weeks earlier.

Later the astronauts met informally with KSC managers and the NASA contractor managers. There had been some teasing of Swigert because he left so quickly when added to the crew that he forgot his income tax. He found a letter from Internal Revenue when he returned. "On the front of it was stamped, 'This is a friendly letter,'" Jack laughingly reported.

"One intangible thing came out of this," Swigert observed, "It not only brought all factions of our nation together, we even forgot racial problems and things like that, but it also for a brief moment united the world. I guess that is something that perhaps God in his wonders had intended to show that perhaps we can all live together at some point in time."

Dr. Cortright presented the Review Board's findings to NASA June 15 while former Astronaut James McDivitt, now Apollo program man-

ager at the Manned Spacecraft Center, continued a task force effort to work out sure means of preventing a similar incident. NASA would make whatever changes were required in spacecraft and procedures. That was Dr. Paine's assurance to press and public following release of the complete investigative report which demonstrated brilliant technical detective work.

The Board found that two thermostatic switches installed in the service module's oxygen tank, which controlled electrical feed to heating tubes within the tank, probably froze in closed position before launch and after the countdown demonstration test. Switch failure was blamed upon a change in specifications directed by North American Rockwell in 1965, increasing the direct current voltage to 65 from the normal 28 employed in flight. The Beech Aircraft Company, which supplied the tank, did not uprate the switches and continued to install the same type rated for flight voltage only. Apparently no one at North American Rockwell, the Manned Spacecraft Center or Kennedy Space Center knew the switches had not been changed. When KSC encountered trouble in detanking 12 days before launch, after discussing the problem with the contractors and MSC, it was decided to energize the heaters and pulse gaseous oxygen into the tank in order to force the liquid oxygen out. Test specifications controlling the launch preparations, which are supplied to KSC by the Manned Spacecraft Center, called for 65 volts. That amount was used as it had been in all previous Apollo spacecraft.

As a result of the switch failure, subsequent testing for the McDivitt investigators and the Review Board disclosed that pressure rose in the tank, wiring ignition apparently ignited creating still more pressure, and the result was fire that ruptured the tank and caused the failure in flight. The Review Board therefore recommended that the Apollo organization take steps to remove all potential ignition sources and combustible materials from future oxygen tanks. Those precautions would necessarily be taken before Apollo 14 left Earth for the Moon.

The Apollo 13 crew met with senior Government and contractor management following ceremony in Vehicle Assembly Building May 4. Commander James Lovell addresses group. Command Module Pilot John Swigert is seated at left, Lunar Module Pilot Fred Haise at right.

XVI

Unmanned Launch Operations

THE launches of unmanned spacecraft, some for scientific objectives, others for missions directly benefiting society, far outnumber the manned launches conducted by the Space Center. They increased in frequency and variety of spacecraft in recent years, making use of medium class launch vehicles such as the Delta and the more powerful Centaur, fueled with liquid hydrogen.

John J. Neilon succeeded Dr. Robert H. Gray as director of unmanned operations carried out by the Launch Operations Directorate at Eastern and Western Test Ranges in June 1970. The highly competent Government-industry team had conducted 146 launches between 1956 and 1970, of which 125 were successful. While most of these occurred at NASA Complexes on Cape Kennedy Air Force Station, an increasing number of missions are being launched from the Western Range at Lompoc, California which, by nature of the geography, is better suited to high inclination orbits.

Most of NASA's scientific satellites are prepared by or under the direction of the Goddard Space Fight Center, at Greenbelt, Md. Those designed for lunar reconnaissance in advance of manned Apollo landings — Ranger, Orbiter, and Surveyor — were prepared under supervision of the Jet Propulsion Laboratory in Pasadena, Calif., operated by California Institute of Technology under NASA contract. JPL first won national acclaim for the Explorer I satellite packaged for the U.S. Army and placed in orbit January 31, 1958 by Dr. Debus and his group as the first U.S. satellite.

A brief explanation may clarify NASA's mission planning which decides the kind of spacecraft, and the experiments they carry, to be provided to the launch center. The agency's headquarters manages space flight projects through three major departments. The largest is the Office of Manned Space Flight directed by Dale D. Myers. OMSF prepares the schedule and determines the missions of all Apollo launches.

Another major department, the Office of Space Sciences and Applications, directed by Dr. John Naugle, plans the unmanned scientific space exploration missions, or makes arrangements for NASA launchings of satellites provided by the Communications Satellite Corporation, or the Environmental Science Services Administration or foreign nations. The Office of Advanced Research and Technology, the third NASA department, conducts exploratory programs seeking to develop new materials, fuels or technology which may subsequently be applied in aeronautics or space flight. Mr. Gray's team conducts launch assignments for OSSA and OART. NASA research centers operating under both major departments procure the launch vehicles and spacecraft which are then flown from Cape Kennedy or the Western Test Range.

Key members of the Space Center's unmanned launch team include men who have been active in space research 10 or more years, like Mr. Neilon whose association dates back to Project Vanguard. His colleagues include W. C. Bubbers, Chief of Program Control and Requirements; M. R. Comer, Jr., Staff Engineer; J. W. Johnson, Technical Assistant to the Director; J. L. Richardson, Chief Administrative Officer; F. J. Stevens, Chief, Range Operations; D. C. Sheppard, Chief, Spacecraft and Vehicle Support Operations; J. D. Gossett, Chief, Centaur Operations; Hugh A. Weston, Jr., Chief, Delta Operations; Harold Zweigbaum, Chief, Technical Support Operations; H. R. Van Goey, Manager, Western Test Range Operations; and J. B. Schwartz, Deputy Manager.

They are supported by launch vehicle or stage contractors including McDonnell Douglas, Delta vehicles; General Dynamics/Convair, Atlas and Centaur vehicles; Western Electric Co., Delta radio command guidance and Minneapolis Honeywell Co., Centaur inertial guidance. NASA's Lewis Research Center brought the Centaur vehicle to operational status, having taken over the development project from the Marshall Space Flight Center.

The directorate supervises integration of spacecraft and launch vehicle activities, determines telemetry and photographic data requirements and coordinates Eastern Test Range support. The responsibility for spacecraft checkout requires the team to work closely with the spacecraft designers, sometimes five years prior to launch, in order to prepare ground supporting systems for the peculiar requirements.

Many historic firsts are credited to the team, including the following:

Sept. 18, 1959—Vanguard III launched for NASA to measure solar X-rays, environmental conditions in space and Earth's magnetic field.

April 1, 1960—Tiros I, a 270-pound NASA meteorological satellite, relayed thousands of cloud cover photographs for use in weather forecasting, demonstrating the effectiveness of satellite-borne observations

in this field. Employment of weather observation stations of this type has been called the greatest advance in meteorology since the invention of the barometer.

Aug. 12, 1960—Echo I, NASA's passive communications satellite, a giant balloon-shaped object, was placed in orbit.

Aug. 23, 1961—Ranger I spacecraft placed in low Earth orbit testing the NASA payload designed to impact on the Moon and transmit close-up photographs of the surface before crashing.

March 7, 1962—OSO-1, first of NASA's orbiting solar observatories, provided data on approximately 75 solar flares.

July 10, 1962—Telstar I, first commercial communications satellite launched for the American Telephone and Telegraph Corporation on a NASA vehicle.

Aug. 27, 1962—Mariner II, first successful interplanetary probe of Venus.

July 26, 1963—Syncom II, first operational communications satellite placed in synchronous orbit.

Feb. 24 and March 27, 1969—Mariner Mars VI and VII were launched. Mariner Mars VI passed within 2,000 miles of the planet on July 31, 1969, obtaining photography of the equatorial region, and Mariner Mars VII passed within 2,000 miles of Mars August 5, obtaining excellent photography of the planet's polar region.

LAUNCH RECORD OF ULO TEAM

	Vanguard	Delta	Atlas-Centaur	Atlas-Agena	Thor-Agena
1956	1				
1957	3				
1958	6				
1959	4				
1960		3			
1961		3			
1962		9			
1963		7	1		
1964		5	2	5	2
1965		8	2	2	2
1966		8	4	5	2
1967		12	4	6	1
1968		8	3	1	1
1969		11	3		2
1970*		4			2
	14[a]	78[b]	19[c]	19[d]	12[e]

[a]6 successes, [b]71 successes, [c]15 successes, [d]18 successes, [e]11 successes

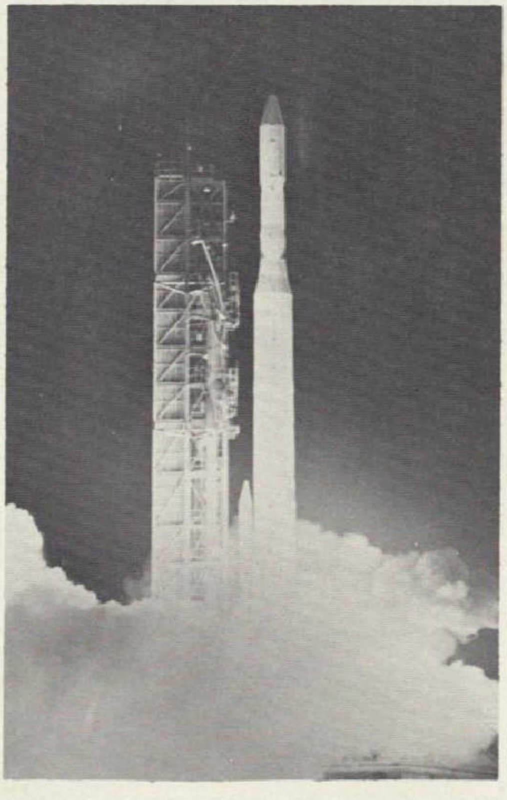
The team also launched 2 successful Thor rockets in 1962, and 2 successful Atlas D rockets in 1964 and 1965.

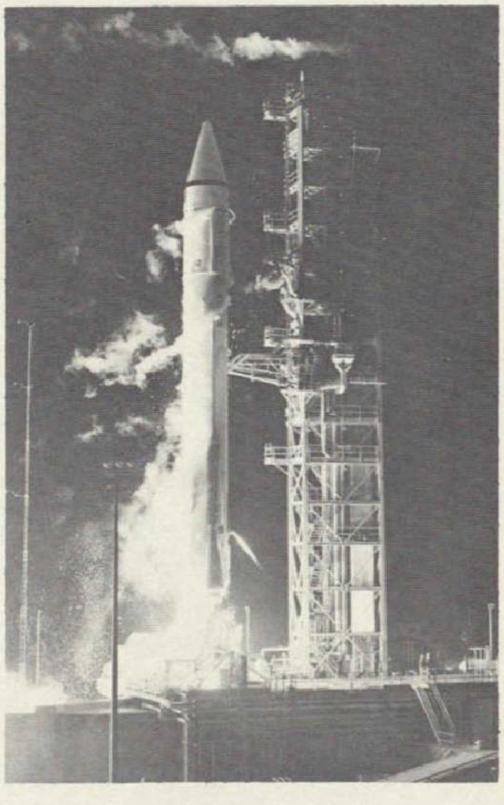
*Through June 1970

The team also launched three other Rangers, some of which returned excellent photographs of the lunar surface. Other Mariners were flown to Venus in 1964 and 1967. Five Lunar Orbiter spacecraft photographed the Moon from low orbits. Five Surveyor soft landing spacecraft televised close-range pictures of the surface and actually sampled the chemical content of the Moon's crust, described as resembling wet sand. These exploratory missions greatly enhanced knowledge of lunar terrain and environment, and provided essential information to assist Apollo astronauts in selecting landing areas for their spacecraft. The data was valuable to scientists preparing the type equipment carried by the astronauts which was left on the Moon.

Scientific spacecraft were launched from both Eastern and Western Test Ranges for nations cooperating with the United States in space research. Canada, the United Kingdom, France and European Space Research Organization have employed NASA rockets and the services of KSC. The team launched Early Bird and Lani Bird satellites for the

Left: As a Delta vehicle carries sceintific satellite into orbit, the booster rockets which increase thrust are plainly visible on both sides of the first stage. Right: Centaur lifts off Complex 36 to carry a Surveyor spacecraft that soft landed on the Moon.





Communications Satellite Corporation, permitting relay of live television images across the Atlantic and Pacific Oceans as well as audio transmissions. COMSAT reimburses NASA for the cost of the launch vehicles and launch services, but provides its own satellites. Improved weather satellites furnished by the Environmental Science Services Administration in support of the weather forecasting servicing have also been flown, ESSA reimbursing NASA for launch costs.

The unmanned spacecraft are prepared for flight in Cape Kennedy laboratories by the mission NASA center or, in the case of ESSA and COMSAT, by the sponsoring agency. Experimenters who designed the research instrumentation perform the necessary checks and tests. The Jet Propulsion Laboratory maintains a small, permanent complement at Cape Kennedy to prepare its spacecraft, under the managership of Henry Levy.

NASA utilizes several facilities on Cape Kennedy for unmanned launch operations including:

Hangar AO—where the Jet Propulsion Laboratory prepared Surveyor, Mariner, and other lunar and interplanetary spacecraft. A control center in the building communicates directly during launches with the Pasadena installation and the deep space tracking stations operated for NASA by JPL.

Hangar AE—where most satellites carried on Delta vehicles are prepared for launch. Mr. Gray maintains a mission control center in this building for the spacecraft controllers, but he directs the actual launch operations several miles away in a blockhouse adjacent to the launch pad.

Hangar AM—where other spacecraft such as orbiting geophysical observatories, Pioneer, and advanced technology satellites are prepared.

Hangar S—where Lunar Orbiters and biosatellites are prepared. Biomedical handling devices were installed with cages for live specimens. The second biosatellite launched Sept. 7, 1967 was recovered for NASA by the Air Force over the Pacific Ocean when it reentered. Its specimens were then available for examination by scientists interested in the effects of weightlessness and radiation upon plants and other organisms.

The team utilizes two spin test facilities near the launch complexes to install hypergolic propellants and pyrotechnics, and to balance spacecraft prior to mating them with the carrier rockets.

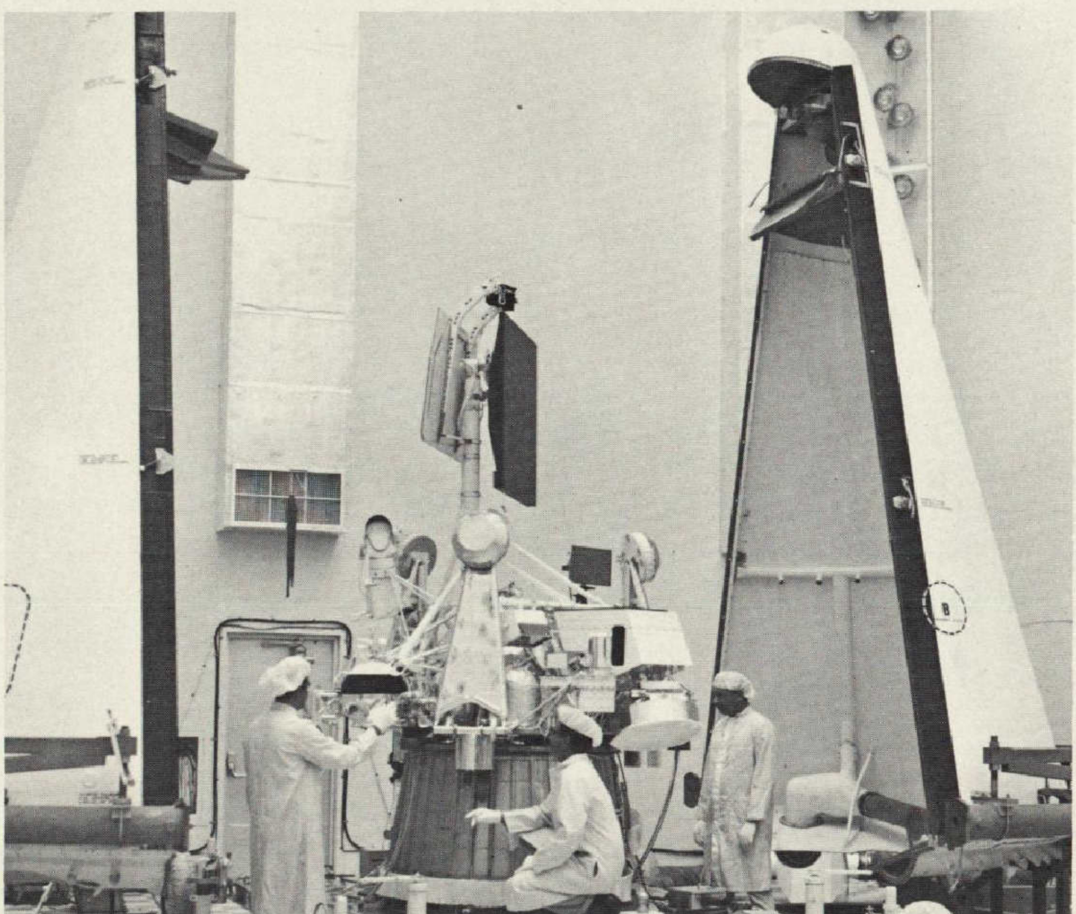
Launch Complexes 12, 13, 17 and 36 have accommodated the Delta, Agena, and Centaur vehicles. Delta, with the Thor booster stage developed by Douglas Aircraft and upper stages initially evolved from early Vanguard rockets, has won recognition as the work horse of the unmanned space program. More than 75 of these three-stage vehicles have been launched by NASA with a high success ratio. They carried a wide range of spacecraft, including Tiros and ESSA meteorological

satellites, communications satellites, and solar observatories. Complex 17, from which Delta is launched on either of two pads, has two service structures controlled from the same blockhouse.

NASA has made use of several Delta configurations, selecting each for a specific mission. These launch vehicles are from 72 to 90 feet tall and vary in thrust, or boost power, from 87,000 pounds to 170,000 pounds. Solid propellant booster rockets are installed on the first stage to augment liftoff thrust.

Two-stage Atlas Agena vehicles, more powerful than Delta, were flown from Complexes 12 and 13. They carried Ranger spacecraft, Lunar Orbiters and Mariner space probes to Venus. Essentially the same vehicle was employed by NASA Gemini launch team to place Agena target vehicles in orbit for rendezvous and docking maneuvers executed by Gemini

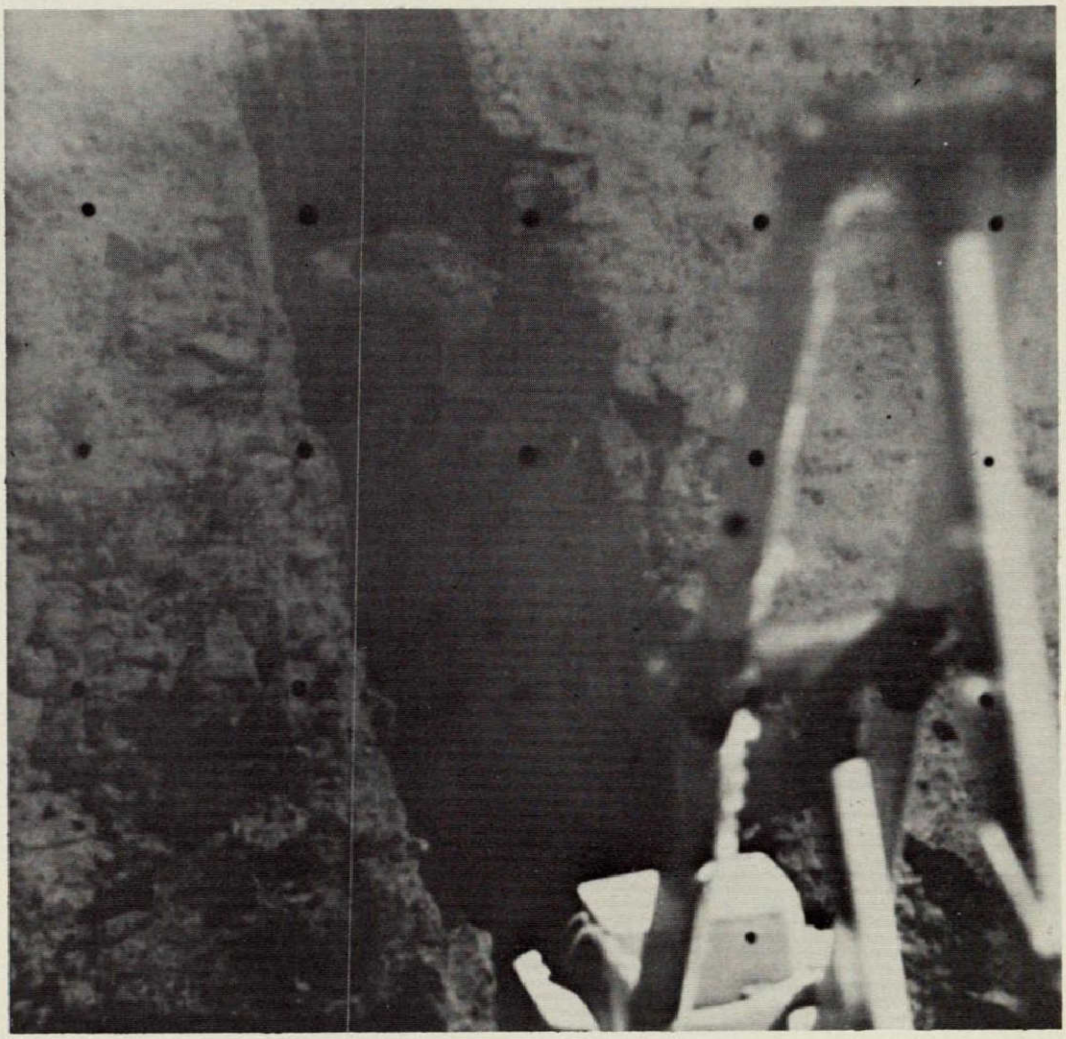
Engineers painstakingly checked out scientific instruments carried in Surveyor spacecraft before it was launched to the Moon by Centaur vehicle.



astronauts. For these missions, Agenas were launched from Complex 14 where Mercury astronauts began their flights. NASA has discontinued use of the Agena, preferring the more potent Centaur configuration, at the Kennedy Center.

For its Centaur booster, NASA constructed a new launch facility, Complex 36, with two service towers and two pads. Centaur was the first U.S. vehicle to utilize liquid hydrogen fuel that had a greater thrust ratio than conventional jet fuel, or kerosene, employed in the first stage of most liquid propellant launch vehicles. Centaur is mounted on an Atlas main stage which serves as the booster.

Photograph transmitted by radio from the Moon's surface by Surveyor reveals, in center, dark smear which is really a shallow trench scooped out by Surveyor's metal claw visible in lower right foreground.



Centaur stands 100 feet tall and develops 388,000 pounds thrust at liftoff. The Centaur upper stage imparts 30,000 pounds thrust. This vehicle can insert payloads of 8,500 pounds in Earth orbit, fly 2,300 pounds to escape velocity, or 1,300 pounds to Mars and Venus. While main engines of the Agena vehicle had the same thrust as Atlas Centaur, the Agena stage imparted 16,000 pounds thrust. Thus, it could orbit 5,950 pounds, carry 950 pounds to escape velocity, or 600 pounds to the vicinity of Mars and Venus.

Centaur was the first vehicle launched by the Center in 1968, carrying Surveyor 7 to a perfect, soft landing on the Moon. This was the last of the Surveyor series and, like its predecessors, transmitted hundreds of closeup photos of the lunar terrain and scientific data on lunar rock formations. From these spacecraft, Earthbound scientists learned that across the Moon's equator, the most likely area for manned landings, the rock closely resembles basalt, the extruded, hard and black rock which comprises the famed Palisades along the Hudson River and also occurs elsewhere in this country and abroad. On the other hand, Surveyor 7 had been deliberately guided to a landing where Lunar Orbiter photos revealed sharp, irregular cliffs. There the chemical composition of the rock was unlike any known on Earth.

The 1969 launches involved communications satellites, solar and interplanetary scientific satellites, and weather observers including those flown from the Center's launch area at the Western Test Range. One promising enterprise was a cooperative undertaking with the European Space Research Organization, or ESRO as it is known. Scientists of 12 nations selected experiments for space flight and contracted with the Junkers firm of West Germany to assemble and package the satellite called HEOS, for Highly Eccentric Orbit. The Kennedy Space Center team launched the satellite December 5, 1968 while the Europeans who designed it watched the operation. ESRO reimbursed NASA for the cost of the Delta vehicle and launch services.

Looking to the near future, the Kennedy unmanned launch team anticipates a major event in two or three years with the flight of a large spacecraft, Viking, capable of soft-landing on Mars. The vehicle will be a combination of Titan III and the Centaur stage.

As a result of the brilliant record compiled by the team, NASA has awarded to Dr. Gray the Exceptional Service Medal and has presented a number of Group Achievement Awards to the organization. The Delta and Tiros Project Groups of the Goddard Space Flight Center received the first of these awards in 1963. Two years later the award was conferred on Goddard's Launch Operations Division for "outstanding achievement and significant contributions to mankind's understanding of space for orbiting unmanned spacecraft." Several other group achieve-

ment awards have recognized the group's participation in the Atlas Centaur, Atlas Agena, Nimbus, Orbiting Astronomical Observatory, Mariner and Lunar Orbiter projects."

As the Director of Unmanned Launch Operations, Mr. Gray coordinates the Center's project management relationships with other NASA development centers and the Office of Space Science and Applications. These agencies provide the funds to KSC to carry out their launches.

There is much more of direct relationship between the unmanned, or scientific type space launch program, and manned space flight than is generally understood. An outstanding illustration involves five spacecraft launched over a 40-day period prior to December 21, 1968 when Apollo 8 began its precedent-breaking mission. These spacecraft played a part in the success of Apollo 8 in terms of safety, communications and other aspects.

Three days before the lunar journey began, KSC unmanned launch group placed in orbit Intelsat III, the most sophisticated of the growing commercial family of satellites owned by the 63-nation consortium. On Christmas Eve, Intelsat III was on station 22,300 miles above the Equator over the Atlantic Ocean and for the rest of Apollo 8 mission handled its share of television and voice coverage of the flight. It was launched from Complex 17 of the Kennedy Space Center.

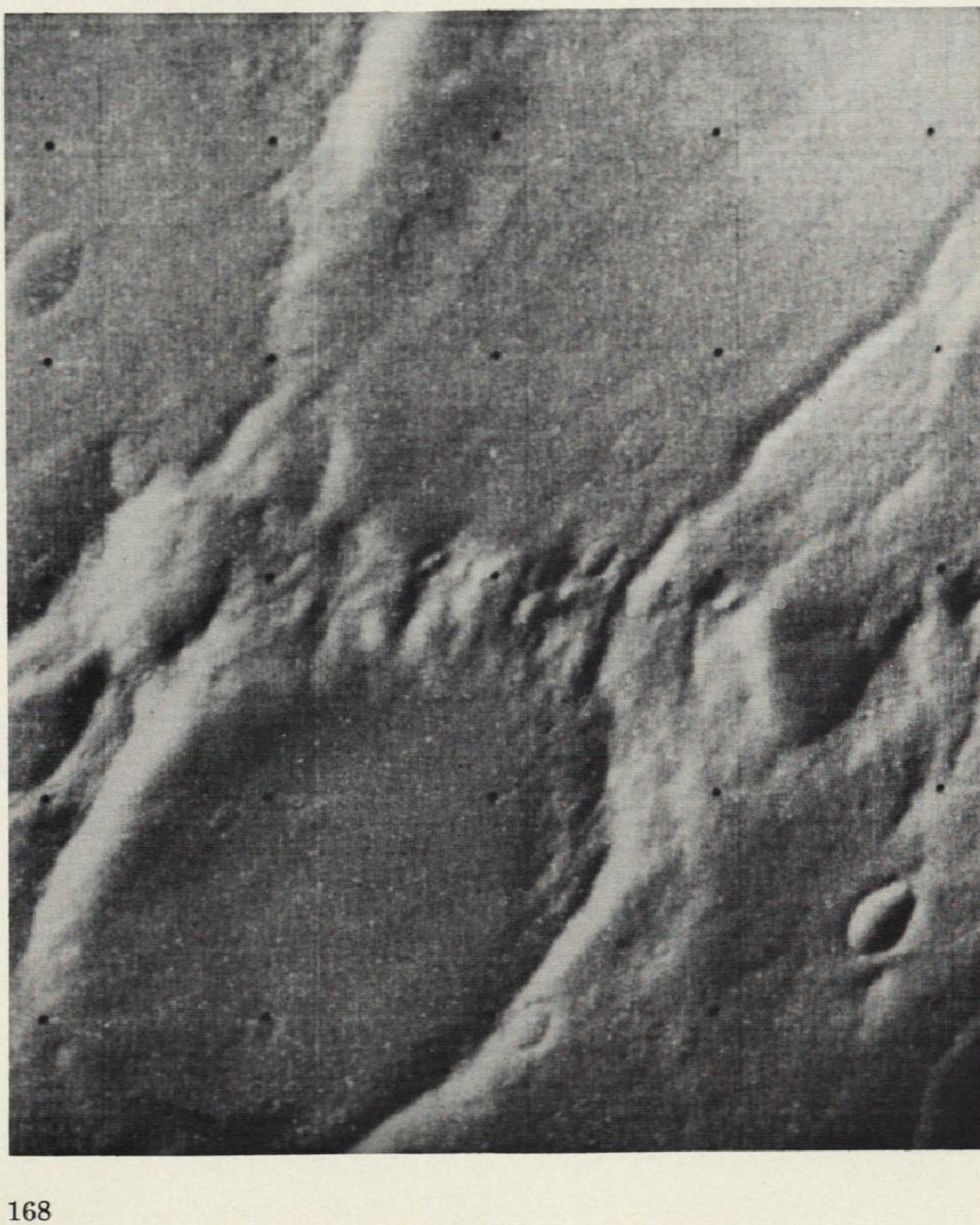
Six days before the Apollo 8 launch, from the one KSC launch complex at the Western Test Range, ESSA VIII was placed in circular, near-polar orbit. It provided automatic picture transmission photographs of cloud cover and wind streams employed by weather forecasters at Kennedy and at Honolulu during the Apollo flight. Three other automated satellites, the Orbiting Astronomical Observatory flown from Complex 36 at Kennedy December 7, the European Space Research Organization satellite, HEOS, launched December 5 from Complex 17, and Pioneer IX, launched November 8 from Complex 17 furnished daily reports about radiation changes, flares and other conditions on the Sun's surface, including the side hidden from Earth, which provided vital clues in the space weather forecasts that predicted safe radiation levels during the Apollo 8 mission.

Other NASA spacecraft launched earlier, such as the Applications Technology Satellites I and III, were extensively employed to augment the coverage available from the Communications Satellite Corp.'s orbiters. Thus, ATS I, in orbit over the Pacific, initially relayed television coverage of the Apollo 8 splashdown events to a station at Brewster, Maine from which it was transmitted via other satellites and ground lines to networks throughout the Free World. Comsat's satellites over the Atlantic and

Pacific Oceans made available about 100 of their 240 two-way voice circuits to handle NASA support communications with the Apollo 8 in space.

Clearly, the manned journey to the Moon and back made good use of space technology contributed by NASA and U.S. industry.

Photographed from 2,000 miles by Mariner 7, two craters near the south polar cap of Mars appear as a giant footprint.



XVII

Air Force Support

SINCE the space program began, NASA has launched manned and unmanned vehicles from complexes on Cape Kennedy Air Force Station. Each complex is made up of a blockhouse, or launch control center; service tower, umbilical tower, launch pad or pedestal on which the vehicle is erected, and related ground equipment.

The Air Force Eastern Test Range manages the Department of Defense base and provides services essential to the conduct of NASA launch operations, including maintenance of the complexes, fire and security protection, and safety. A cordial and effective working relationship exists between NASA and the Range to the mutual benefit of both and to the taxpayer's advantage as well.

When the United States embarked upon the development of long-range, rocket-powered weapons systems at the close of World War II, the military searched for a suitable proving ground. They needed a base where rockets could be checked out, assembled, fueled and fired without endangering the surrounding community, and they needed the means by which to record details of their test and flight performance in order to achieve reliability and effectiveness in these powerful weapons. Thee locations were considered, two on the West Coast and the third at Cape Canaveral, Florida. The Cape was selected because of its favorable climate, growth potential, the availability of the nearby deactivated Banana River Naval Air Station, and the presence of down range islands which made excellent sites for tracking stations.

Congress authorized the Secretary of the Air Force to establish a joint long-range proving ground May 11, 1949. Agreement had previously been reached with the United Kingdom by which the United States obtained use of the Bahama Islands for future tracking stations. Today's Eastern Test Range extends far beyond its original terminus on Ascension Island in the southeastern Atlantic Ocean. By employing

specially equipped aircraft and ships, the Range can track rockets fired from Cape Kennedy until their payloads impact in the Indian Ocean 10,000 miles away.

Twenty miles south of Cape Kennedy, on the site of the former Naval Air Station, the Air Force installed Range headquarters, technical laboratories and other facilities. The work force of 17,663 consists of 4,374 military personnel, 3,298 Federal Civil Servants, and 9,991 contractor employees whose activities require an annual budget of about $161,000,000. Of the total work force, 3,243 are stationed on down range islands. Pan American Airways is the base contractor while Radio Corporation of America functions as the technical instrumentation subcontractor, operating the tracking stations as well as performing other specialized services for the Range and its users.

The Air Force tested a number of weapons systems from the Cape including Snark, Matador, Mace, Thor, Atlas, Titan and Minuteman. Presently, the Air Force Systems Command conducts launches of the 2,200,000-pound thrust Titan III-C configuration from Complexes 41 and 42 which placed in Earth orbit a fleet of satellites for world wide defense communications. The Army built three launch complexes for its Redstone, Jupiter, Jupiter C, Juno and Pershing rockets while the Navy sited its test facilities for Polaris in the southeast portion of the installation. Navy is conducting development tests of a new and more powerful submarine launched rocket, Poseidon.

Following the acquisition by NASA of the Merritt Island launch area, the agency turned over to the Air Force submerged land in the Banana River contiguous to the Cape. Here the military dredged and filled an extensive area on which the launch facilities for Titan III-C were constructed. This system employs a mobile concept of operations, utilizing diesel engines, railroad flat cars and rails to move the assembled vehicle to the firing site.

Major General David Jones commands the Eastern Test Range, having succeeeded in 1967 Major General Vincent Huston who became Deputy Chief of Staff for Operations, Air Force Systems Command. General Huston commanded the Range during the Gemini program and supervised Defense recovery operations for the spacecraft and astronauts as well as overseeing support provided to NASA in the launch phase. Like his predecessor, General Jones has had a close association with missiles and space developments for many years. One of the group who flew the Doolittle raid on Tokyo in World War II, his distinguished career has included several years on detail in NASA Headquarters as a Deputy Associate Administrator for manned space flight programs.

NASA has been a major tenant on the Cape since 1958, occupying

hangars, laboratories and offices initially constructed for the Army and other users, and has built several facilities in the intervening years. The agency was, in 1967, occupying seven launch complexes of which three were built expressly for the space program. Complexes 34 and 37 were designed for the Saturn I vehicles and subsequently modified for the Saturn IB, Complex 36 has two gantries, or service towers, and two pads for NASA's Centaur vehicle which soft landed Surveyor spacecraft on the Moon.

Four other complexes once employed in space launches are no longer used — Complex 14, from which Mercury astronauts began their history-making orbital flights and from which Agena target vehicles were launched; Complex 26, from which the first U.S. satellite was launched; and Complex 56, where Alan Shepard became the first American space pilot in a Mercury Redstone. The Air Force transformed Complex 26 into a very complete rocket museum. On adjacent Complex 56, NASA exhibits the Jupiter C vehicle used for the first satellite and the Mercury Redstone which launched Shepard and the late Virgil Grissom.

The Range provides common services to tenant agencies, including NASA, such as scheduling, communications, range safety, data acquisition and processing, environmental safety, radar tracking systems, telemetry systems, and recovery. The Air Force also maintains laboratories conducting research and development related to rocketry, tracking and data reduction.

Range safety officers play a key role in all launch operations. To minimize the inherent risks when a multi-ton rocket thunders into space, the safety officer must know continuously until its engines cut off where the vehicle is and, more importantly, where it will impact. The point where a rocket will fall into the sea, once its propulsive force has terminated, is as inexorably fixed as the impact point of a stone at the instant it leaves a boy's hand.

In order to track a rocket constantly through powered flight, the Range employs tracking, measuring and computing devices in redundant electronic systems. The safety officer, located in the Central Control building on Cape Kennedy, knows from the instant of launch where the vehicle is, the deviation of its flight path from a fixed reference line, and the point where it will impact if thrust is terminated. He also has displayed before him the pre-planned trajectory, the limits of the rocket's path, and so-called destruct lines which tell him when he must destroy the vehicle if it behaves erratically.

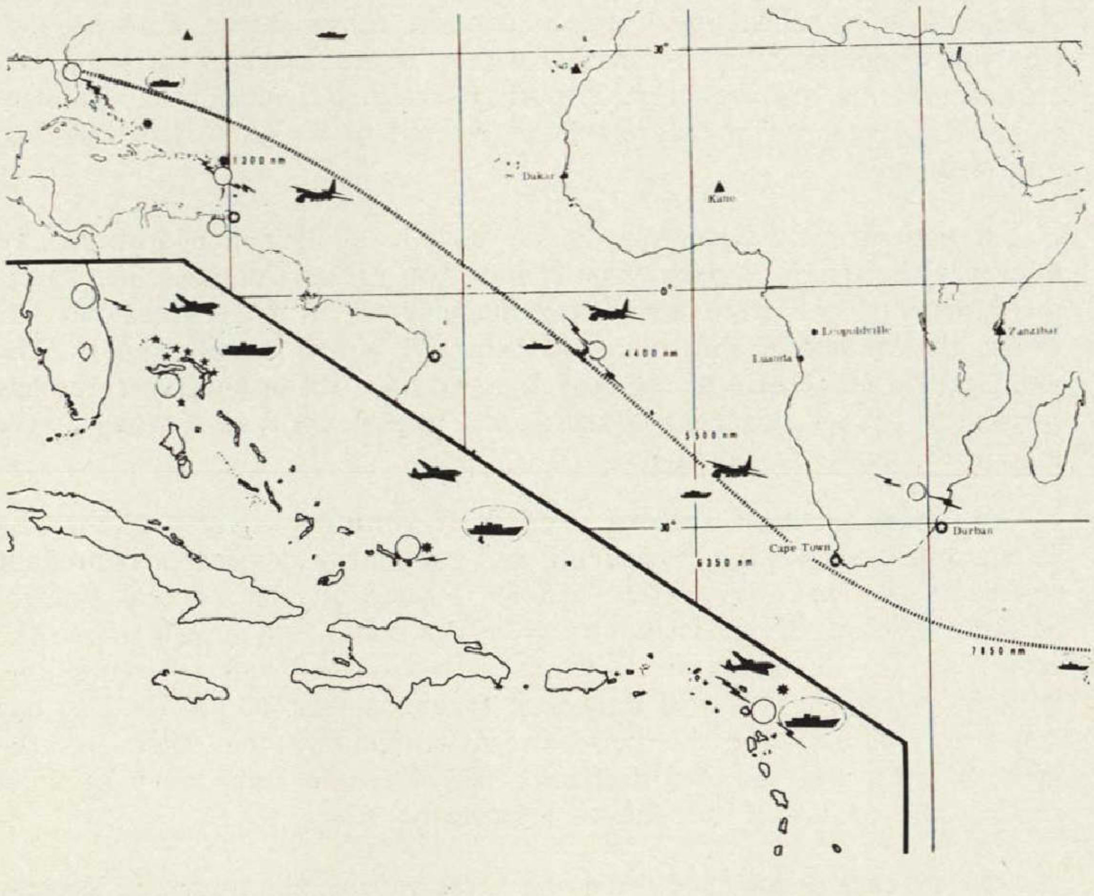
Every rocket launched from the Cape carries the means to destroy

40

it — high explosive charges placed on the fuel tanks and, in the case of liquid propelled rockets, a device to stop the flow of propellant. Two radio receivers, a primary and a backup, are carried in each rocket to assure reception of destruct signals transmitted by the Air Force safety officer. Because of the tremendous costs involved in building a rocket and its payload, and preparing the entire Range for a single flight, the safety officer exercises prudent judgment to avoid unnecessary destruction. In the early years of developing the long-range weapons systems, circumstances compelled him to destroy quite a few vehicles. Modern rockets have become much more reliable.

Old-timers on the Cape remember some of the more sensational incidents when rockets either blew up at launch or had to be destroyed shortly after liftoff. An early Redstone rose off the pad, turned over and flew horizontally toward the Cape's industrial area. Fortunately, it nosed down and struck the palmetto scrub a few hundred yards from the main fire station. Some time later when Polaris was undergoing

Eastern Test Range extends from Cape Kennedy to Indian Ocean.



early flights from an underground launch cell, the rocket popped above the ground, ignited and veered toward the town of Cape Canaveral. The range safety officer blew it up, but fragments fell into an occupied trailer court while the flaming booster impacted on the Cape and ignited the scrub. No one was injured, but for some days thereafter, guards roamed the roads on Cape Kennedy shooting rattlesnakes crawling out of the burning underbrush.

While flight safety is understandably important to the personnel engaged in launch operations, to residents of adjacent populated areas and on off-shore islands, the designers and builders of vehicles and spacecraft want to know everything possible about their performance during powered flight through Earth's atmosphere, in the vacuum of space, and reentry into the atmosphere in the case of manned craft. A complex and highly specialized technology has grown up to meet this need and employs some of the most sophisticated equipment ever devised, including powerful radars, electronic cameras, and large computers, much of it linked in an elaborate network of cable running overland as well as along the ocean bottom.

Sensing devices are installed in rocket stages and spacecraft which monitor functions and events of interest to the launch team and the organizations responsible for the vehicle and cargo. The number of measurements increases with the complexity of the vehicles. For example, 116 different measurements were monitored during the flight of a Redstone and recorded at ground stations either on the Cape or the down range islands. About 400 functions were monitored during the flight of an Atlas, while in an early test of a Titan II rocket, over 2,000 events were sensed. NASA obtained approximately 1,250 measurements from the Saturn I vehicles and recorded 3,200 events during the Saturn V flight November 9, 1967.

The information, referred to as data, is flashed back to the telemetry stations by radio and recorded on magnetic tape and oscillograph paper, miles of which are consumed every year by the Range. NASA provides the Air Force, in advance of launch, with a list of the measurements desired during pre-launch testing as well as during actual flight. On a manned launch, the Kennedy Space Center utilizes its own telemetry systems as well as receiving data directly from Air Force sources, records the information in the Central Instrumentation Facility and feeds duplicate data in real time to the Manned Spacecraft Center in Houston, Texas or the Marshall Space Flight Center in Huntsville, Alabama.

Many cameras, of differing types, are focused on a rocket to provide optical data — specific markings are placed on the vehicle's outer skin to

facilitate the photographic coverage. For a Jupiter launch, Army might request the Range to install 40 cameras while for the Saturn V space vehicle, the quantity jumped to 157, of which 100 recorded engineering type coverage. Timing is automatically inscribed on the exposed frames of film. Airborne cameras are utilized in manned launches. High-speed jet aircraft zoom in on the ascending vehicle and pursue it until the accelerating rocket leaves them far behind. Most of the launch vehicles attain velocities of 5,000 miles per hour in approximately three minutes of powered flight. During 1966, the Range provided 617,664 feet of motion picture film to NASA.

Some vehicles, such as Saturns, have been flown with cameras mounted on and inside them. The cameras are placed in cassettes which may be released when the stage impacts in the ocean, or may be triggered to drop off before impact occurs. To recover the film the Air Force deploys planes and ships in the predicted area. The actual recovery is achieved by pararescue men who dive into the sea wearing inflated rubber suits and other gear familiar to skin divers. The Eastern Test Range also becomes a part of the overall Department of Defense recovery operations for NASA's manned spacecraft when the splashdown occurs in the Atlantic several hundred miles east of Cape Kennedy.

Tying together the radar and telemetry systems is an extensive communications network utilizing radio, a 1,500-mile submarine cable, microwave, underground telephone and video cable, and high frequency ground-to-air and ship-to-air radio systems. The Cape Kennedy launch base represents one of the largest and most flexible communications plants ever installed within such a concentrated area — the Cape covers 17,000 acres. There are 265,000 circuit miles of buried cable, 6,560 circuit miles of wideband video cable in a closed circuit television system, 2,500 operational intercom instruments, 11,000 telephones, and 200 trunks linking the Cape with the world outside.

The Air Force Eastern Test Range exercises overall responsibility for scheduling launch operations on behalf of its tenants. During the months before a given launch, plans must be formulated to provide normal support and many unusual aircraft or ship movements which may be necessary. Aircraft may be flown from Brazil, Ascension Island, or bases in South Africa to cover desired areas in either the South Atlantic or Indian Ocean. This frequently requires obtaining foreign clearances for aircraft and crews, and arranging for maintenance. Ships equipped with electronic gear for tracking and telemetry must be moved to desired locations.

After the vehicle reaches the launch pad, support tests are run continuously to check, calibrate, and confirm that the instrumentation

and rocket systems are ready for flight. As these tests proceed, the radio transmitters carried in the vehicle relay functions and conditions as they occur. Tracking devices in the rocket are triggered and calibrated by range radars. Camera coverage is arranged. All of these interrelated functions must be scheduled as the user desires, or as the Range determines that safety considerations dictate.

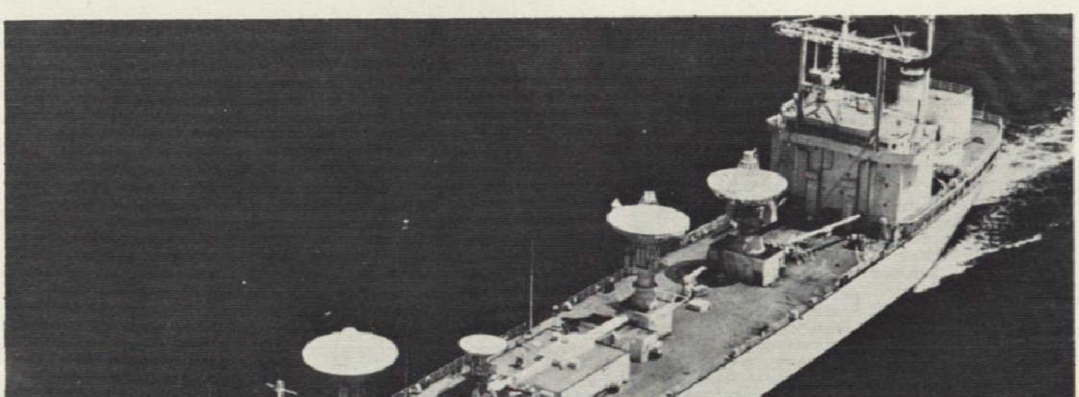
To maintain a safe working environment, the Range analyzes propulsion, ordnance, high pressure gas, and flight termination systems which yield data leading to calculations of explosive potential, noise levels, and toxicological and radiological hazards. These calculations influence the siting and construction of assembly, launch and support facilities, and the development of safety plans governing work performed on the launch complexes. NASA may impose higher safety standards for its vehicles and spacecraft than the Range, in which case the more stringent rules will be enforced by both agencies.

In return for these and other essential services, NASA contributes to the annual cost of operating the Eastern Test Range. There is a daily exchange of services between the two agencies in the interest of avoiding duplication wherever feasible and in making full use of existing resources, including Air Force telemetry and radar installations which have been sited on NASA's spaceport. The Range maintains and operates eight long-range, specially equipped jet aircraft which function as part of the worldwide Apollo tracking and communications network. Prior to launch, the aircraft move to designated stations from which they can reach positions at high altitude to receive and relay data and voice communications between Apollo and Earth.

The Western Test Range furnishes support to the Kennedy Space Center in similar arrangements for the NASA launch complex maintained near Lompoc, California. This launch facility is especially useful when a polar orbit is desired because the booster flies over open sea areas until impact. Polar orbit for NASA spacecraft can be attained from Cape Kennedy but only by accepting a penalty in terms of payload weight. To launch directly to the South from the Cape means that the rocket would fly over such populated areas as Palm Beach and Miami. So the vehicle is steered to the east on a dog-leg course to avoid overflight of the mainland thence southward over the Caribbean Sea until the satellite is inserted into orbit. The zigzag trajectory requires more fuel and consequently reduces the amount of useful cargo the rocket can boost to 17,500 miles per hour, or orbital velocity. In spite of this, NASA has successfully placed some scientific spacecraft in near polar orbit from the Cape, but has never attempted launching manned spacecraft along such a trajectory.

Above: Apollo Range Instrumentation Aircraft on station over sea areas during Apollo missions receive telemetry data and relay voice communications between the astronauts and Mission Control.

Below: Apollo instrumentation ships track Apollo spacecraft, relay data and voice communications in areas outside the range of land stations.



XVIII

Contractor Support

THE national space program is a joint undertaking of the Federal Government and the aerospace industry. Contractors receive more than 90 per cent of NASA's annual budgets which had been maintained at a level of $3,800,000,000 in recent years. At its peak in 1966, when the budget reached the $5,000,000,000 level, the manned space flight program employed about 300,000 persons, most of them working in industrial plants from coast to coast.

Kennedy Space Center staffing uniquely demonstrates the welding of Government and contractor organizations, many of them with diverse backgrounds, interests and motivations, into an integrated team capable of executing the most complex launch missions. Of the work force employed at KSC, about 17 per cent are Federal employees while the remainder work for resident contractors. Some of these contractors are also engaged in Defense programs at Cape Kennedy Air Force Station where they support the Air Force, Army or Navy.

Kennedy's peak employment was reached in September, 1968 when approximately 26,000 Government and contractor personnel worked in the Space Center. By April, 1969 the total decreased to 23,500 and a further reduction to 17,500 will be accomplished by June 30, 1970 in line with the reduced rate of Apollo/Saturn V launches.

The Apollo program engages more of the Center's resources than any other activity. The contractors who fabricate stages of the Saturn vehicles and spacecraft comprise about one-half the total manpower. Each contractor has a cradle-to-grave responsibility for his product from the time a designer picks up his pen until the stage has functioned in flight as the Government expected, and it must do so for the first time. There is

no second chance, since the stage is normally lost after burnout. Only the Apollo command module returns to Earth and it is not designed for a second flight.

NASA pays its contractors incentive fees, over and above audited costs, which may be adjusted according to the firm's demonstrated ability to meet Government performance criteria and program milestones. NASA rewards the company, in part, according to the performance of its stage in launch preparations and the subsequent flight.

Stage contractors must also satisfy the NASA centers concerned with their work in developing the flight hardware. The development center in manned space flight may be either the Marshall Space Flight Center or the Manned Spacecraft Center. Each has a continuing interest in the contractor's effort throughout design, fabrication, and testing of the stages as well as flight performance.

The Manned Spacecraft Center monitors the work of North American Rockwell, the firm which builds Apollo spacecraft in Downey, California, and the Grumman Aircraft Engineering Company, which produces the lunar modules in Bethpage, Long Island.

The Marshall Center supervises contractors building the Saturn IB and Saturn V launch vehicles. Chrysler Corporation fabricated the first stage of Saturn IB in the same Government-owned plant at Michoud, Louisiana, where Boeing builds the first stage of Saturn V. Marshall also monitors the work of North American Rockwell at Redondo Beach, California where the second stage of Saturn V is produced and the work of McDonnell Douglas Co. at Huntington Beach, California where the firm produces the second stage of Saturn IB which becomes the third stage in the Saturn V configuration. International Business Machines builds the instrument unit for both vehicles under Marshall contracts at Huntsville, Alabama.

Kennedy Space Center employs the same contractors to assist in checking out, assembling, testing and launching their stages at the launch base. Beginning in 1964, the stage contractors increased their work forces as the Saturn launch facilities neared completion and Saturn rockets and Apollo spacecraft were delivered for flight testing in 1965 and 1966. As the manpower grew, Dr. Debus and his management staff recognized the proportions of the challenge that confronted them. In order to balance contractor effort in phase with operating schedules, it was essential to define the specific responsibilities of each and work out clear-cut interfaces, especially in those frequent situations where more than one contractor must work at the same time in the same place. Here the decisions rest with KSC civil servants to determine which contractor has priority and how the work will be integrated.

CONTRACTOR SUPPORT

Each contractor reports to the Center organization having primary interest in his performance. Stage builders operate under supervision of the Director of Launch Operations. Contractors involved in technical communications, instrumentation and launch support receive guidance from the Director of Technical Support. Housekeeping or common services are furnished by contractors reporting to the Director of Installation Support. The firms who design facilities and related equipment report to the Director of Design Engineering.

Dr. Debus organized a Government-contractor staff meeting to facilitate communications between Center managers and the prime contractors. Its membership includes the KSC senior staff and the contractor base managers. They meet frequently to discuss mutual concerns in a completely frank atmosphere.

NASA awards all contracts competitively. In the case of stage contractors, who build parts of launch vehicles or entire spacecraft, the agency selected a firm to carry out the project from beginning to end after formal competition. For example, the McDonnell Aircraft Corporation was chosen to design and fabricate Gemini spacecraft and was the sole producer of these flight articles throughout the program. Similarly, North American Rockwell won the Apollo spacecraft contract as did Grumman for the lunar module.

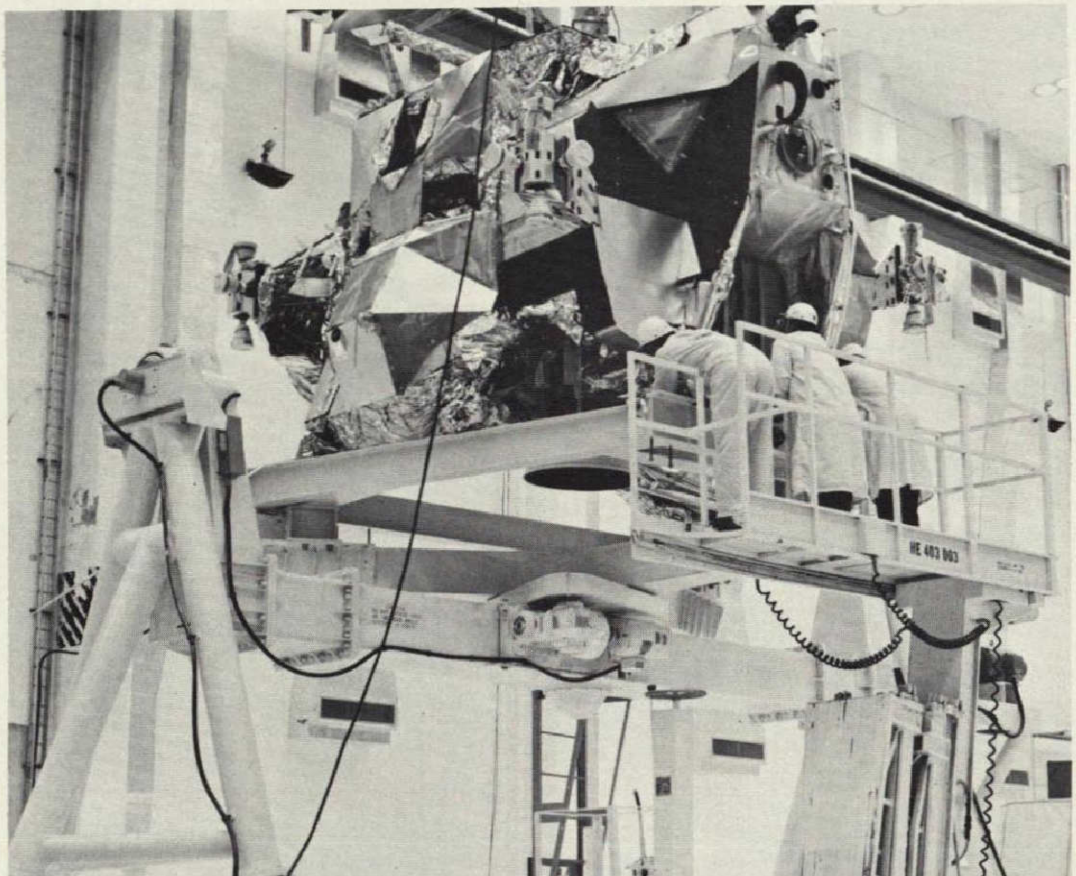
Kennedy's support contractors do not build products. Rather, they provide specialized technical services or common services and were competitively selected also for definite time periods of from three to five years.

NASA's relationships with industry were searchingly examined by Tom Alexander in FORTUNE on the eve of Apollo 11. As he recognized, the agency and its contractors operate as allies against common foes — the hostile environment of space and the treachery of complicated machinery. About 50 per cent of the tasks which must be performed at the launch base are officially classified as hazardous, yet the accident frequency rate runs at a low average that may be jealously considered by industry. The result of this partnership is a new kind of Government-industrial complex, in FORTUNE's judgment, in which each interpenetrates the other so much that it becomes difficult for an observer to identify the other separately. One can sense, in Alexander's words, "an emotional, almost mystical comradeship that seems unique in industrial life."

In this intimately, interdependent situation, only NASA can legally instruct the contractors although their work must be interwoven and coordinated in greatest detail. This is accomplished by publishing elab-

orate schedules which spell out, on minute-by-minute basis, what each contractor will be doing in the launch vehicle and spacecraft. Work schedules are planned or adjusted, when need arises, in advance — always against the known lunar window — in frequent meetings chaired by NASA and attended by contractor technical supervisors. Since the Government people at Kennedy are more knowledgeable than industry

Grumman engineers, in white smocks on test stand platform, anchor the ascent stage of a Lunar Module in preparation for a fit check with Apollo spacecraft.



about launch engineering, the parties meet in an atmosphere of mutual professional respect. The same condition obtains at Marshall, with respect to the Government-industry vehicle team, and at Manned Spacecraft Center where the Government and industry develop spacecraft. Dr. Debus, the Center Director, has observed that in the first year of any new contract at the Spaceport, the company becomes an apprentice, acquiring the hard-won expertise of the Government launch conductors built up since the era of the Redstone and Jupiter ballistic missile systems.

FORTUNE concluded its article by commenting that "if what NASA and industry have learned about management in the Moon program can lead to better ways of pooling diverse abilities for very large tasks — perhaps to putting rationality into man's relationships with his global environment — then the $20-odd billion price of Project Apollo could turn out to be a splendid bargain."

To promote team spirit and enhance morale among Government and contractor personnel, the activities of the Kennedy Athletic, Recreational and Social organization, or KARS, sponsored by NASA KSC Exchange Council, are open to all personnel of the Center. There are athletic events, bowling leagues, golf matches, a chorus, and other group activities. A recreational area, suitably titled Complex 99, has been developed in the south reaches of the Center. The Exchange Council is comprised of civil service personnel elected by their co-workers and financed by income derived from cafeteria and vending machine services.

Dr. Debus initiated a special program for dependents of the Center's employees in 1966, inviting wives to witness major launches from a vantage point a safe distance from the launch sites. During Apollo, approximately 2,500 dependents were admitted for each launch. When Apollo 11 arrived, however, the same opportunity was offered to personnel of NASA Headquarters and the other manned space flight centers. From Marshall came nearly 3,000 employee family members while several hundred also drove to Florida from Houston, Texas and more from Washington, D.C. The KSC Community Relations Branch operates a viewing site for them on Kennedy Parkway North and during Apollo 11 admitted 1,267 vehicles of all types transporting 10,914 men, women and children. Both Government and contractor personnel consider this one of the most effective projects to honor wives whose home life must unfortunately be interrupted by demands of the launch schedule.

These contractors are currently engaged in the national space program at the Kennedy Space Center:

SATURN I VEHICLES

Chrysler Corporation — supplying the 1,600,000-pound thrust first stage. R. F. Gompertz is the systems test director.

McDonnell-Douglas — supplying the second 200,000-pound thrust stage which becomes the third stage when installed in the Saturn V configuration. W. L. Duval is the vice president and director at KSC.

International Business Machines — supplying the instrument unit or guidance system for both Saturn IB and Saturn V. R. E. Ehrhardt manages the IBM facility at KSC.

SATURN V VEHICLES

Boeing Company — supplying the first stage developing 7,500,000 pounds of thrust and providing design engineering support and systems engineering for Complex 39 launch support equipment and integration of launch vehicle assembly. Dean L. Morehead directs Boeing's Atlantic Test Center.

North American Rockwell — supplying the second 1,000,000-pound thrust stage. Thomas J. O'Malley is vice president and general manager for the firm at Kennedy.

McDonnell-Douglas — supplying the third stage of 200,000-pound thrust capability.

International Business Machines — supplying the instrument unit which guides and controls the flight of all three launch vehicle stages.

APOLLO SPACECRAFT

North American Rockwell — supplying command and service modules for Saturn IB and Saturn V.

Grumman Aerospace Corporation — supplying the lunar modules for Saturn launch vehicles. C. E. Kroupa is KSC base manager.

APOLLO SUPPORT CONTRACTORS

Bendix Corporation — launch support services for Complex 39, operating the mobile launchers and crawlers; technical shop operations, maintaining the propellant systems and components laboratory, operating converter-compressors and storing ordnance. Dr. H. P. Bruckner is general manager.

Federal Electric Corp. — supports the Center in technical communications and prototype tracking, operates central data recording and mobile receiving stations, a transmitter information facility, launch control information centers, central timing station, calibration, and scientific computers. T. J. Cameron is project manager.

General Electric Co. — furnishes services and materials for checkout, reliability and integration of launch equipment at Complex 39. E. F. Lowell manages KSC support.

Ling-Temco-Vought/Service Technology Corporation — provides technical services including technical information. McGregor and Werner is a subcontractor for reproduction services. H. J. Hays is LTV/STC project manager.

Pan American World Airways — furnishes detail engineering and drafting support services for the Center. R. B. Madden is Pan Am Project manager.

Trans World Airlines — the Center's housekeeper, operates and maintains production engineering shops, field services, roads and grounds, heavy equipment, mechanical and electrical utilities, mail and postal services, supply operations and janitorial services. Wackenhut Corporation is the subcontractor for security and fire protection. TWA also conducts daily escorted bus tours for NASA. Harry Olander is project manager.

Among other contractors active at Kennedy are the David Clark Co., providing suit technicians for astronaut training and flight pressure suits; Massachusetts Institute of Technology, providing guidance systems for Apollo spacecraft; Link Group of General Precision, Inc., servicing, maintaining and repairing simulators utilized by the astronauts in rehearsing flight missions; Melpar, Corp., supporting the malfunction investigation laboratory; Philco Corp., providing technical services at KSC in connection with the operation of the Mission Control Center located in Houston, Texas; and Radio Corporation of America, who performed essentially the same services from 1964 to 1967 which are rendered by Federal Electric Corp.

NASA's unmanned launch operations require another group of contractors most of whose services are performed on NASA launch complexes at Cape Kennedy or in NASA laboratories there, including:

DELTA VEHICLES

McDonnell-Douglas Aircraft Co.—the prime contractor who prepares,

assembles, checks out and launches the launch vehicles.

Western Electric Co.—furnishes the vehicle guidance package and computes information transmitted from Earth to the on-board guidance system.

Aerojet General Corp.—builds second stage propulsion system motors and tanks, and performs checkout, test and launch monitoring for this stage.

Rocketdyne Division, North American Rockwell—supplies first stage engines and specialized maintenance.

Thiokol Corp.—supplies solid fuel strap-on motors to augment thrust.

CENTAUR VEHICLES

General Dynamics/Convair—supply, checkout, test and launch of the Atlas/Centaur, operating and maintaining Complex 36.

Minneapolis Honeywell—furnishes Centaur guidance system.

TRW Systems—provides technical staff assistance in guidance analysis, reliability, and special studies.

In 1967 NASA sought to strengthen its Apollo system integration by selecting the Boeing Company to perform engineering support, technical integration and evaluation tests for the 15 Saturn V space vehicles in the Apollo program, eight of which have been successfully launched. Originally, in addition to fabricating the Saturn V first stage, Boeing was responsible for supporting the assembly and system integration of the vehicle's second and third stages with the first stage. Later, this responsibility was expanded to include engineering support for the design and modification of Complex 39 mechanical facilities and the operation of certain common use ground support equipment for all Saturn V stages.

In its technical integration and evaluation role, Boeing supports the Apollo Program Office in NASA Headquarters and the three manned space flight centers: Marshall, Kennedy, and the Manned Spacecraft Center. The TIE contract will be completed in FY 1970.

The contractor organizations have been assimilated into the community just as they have become integral elements of the Space Center. They participate in community affairs, contribute to charities, and take active roles in scientific and technical societies which have local chapters and which are attracted to the Space Center environment for regional and national meetings each year.

As the space exploration program continues into the future, other industrial firms will undoubtedly join the ranks of the broadly based complex which has grown up around the NASA installation.

XIX

The Public Interest

SPACE launches from Cape Kennedy, formerly Cape Canaveral, have made the place a common name in the languages of Free World nations — and other nations also. Added to its historic appeal, the unique facilities of NASA's Spaceport have transformed the launch base into one of the man-made wonders of Earth.

Moreover, the basic legislation creating NASA specified the widest possible dissemination of results of the civilian space program. Failures as well as successes of NASA launches were openly exposed. The pressures of the public to see the Spaceport were anticipated by the agency as well as by members of the Congress who were closely associated with the space program. But it was obvious that the restricted access policy which had been enforced for all Cape Kennedy operations during the period when military weapons systems were undergoing test, needed to be relaxed if the public was to become adequately informed concerning space launch operations.

From 1950, when the first rocket blasted off the Cape, until 1963 the Department of Defense tightly controlled all access to the launch base. In mid-December 1963, with approval of Secretary of Defense Robert McNamara, the Air Force Eastern Test Range opened a marked route through the Cape to the public for Sunday drive-through tours. The response clearly demonstrated that the public wanted to visit the installation and see, from their moving autos, the pads from which NASA astronauts, unmanned scientific spacecraft, and military rockets were launched.

Just across the Banana River, construction crews were hard at work building the NASA installation. However, visitors could drive through the area if they chose to risk bumpy and uncertain roads and the competition of trucks, bulldozers and other heavy equipment.

During Congressional hearings on the budget in 1964, the Sub-

committee on Manned Space Flight of the House of Representatives manifested interest in NASA's plans for public visitors. A provision was inserted in the budget act authorizing NASA to spend $1,200,000 for a Visitor Information Center if the agency considered it advisable, and could make funds available from construction monies allocated to the Kennedy Center for other purposes.

By November 1, 1964, the new facilities of the Center were sufficiently ready to permit the same kind of Sunday drive-through tour sanctioned by the Air Force on Cape Kennedy. The visitor had the option to drive through both installations, or either, by using NASA Causeways linking the Spaceport and Cape on the east and U.S. Highway 1 on the west. Again, public response was enthusiastic even though some landmarks on Merritt Island — the Vehicle Assembly Building, mobile launchers, crawlers and service structure — were incomplete. An estimated 400,000 persons enjoyed the Sunday tours in 1964.

Next Spring NASA invited the National Park Service to study the visitor potential and suggest means of satisfying the public demand for infromation. Predicting a gradual buildup to perhaps 3,000,000 visitors annually by the time manned Apollo moon flights were in progress, the Park Service produced a 100-page study that:

—recommended construction of a Visitor Center on the Spaceport

—recommended that NASA provide escorted bus tours for the public at a reasonable charge

—suggested the kind of functions and services which should be available within a Visitor Center to familiarize the public with space exploration and the mission and facilities of NASA.

The study became the basis for planned actions subsequently taken. Later that year, NASA conducted a design competition with the cooperation of the American Institute of Architects and selected a building proposed by Welton Beckett of New York City. A site was chosen on NASA Parkway about seven miles from U.S. Highway 1 and within one mile of the industrial area. It was reasoned that only if the visitor actually stood upon the Center could he feel a true sense of participation. The public would be permitted to drive to this location daily when the Visitor Information Center was completed, inspect exhibits, view films, hear a space lecture and board buses for escorted tours. Or on Sundays, the public could drive through the Center in private vehicles.

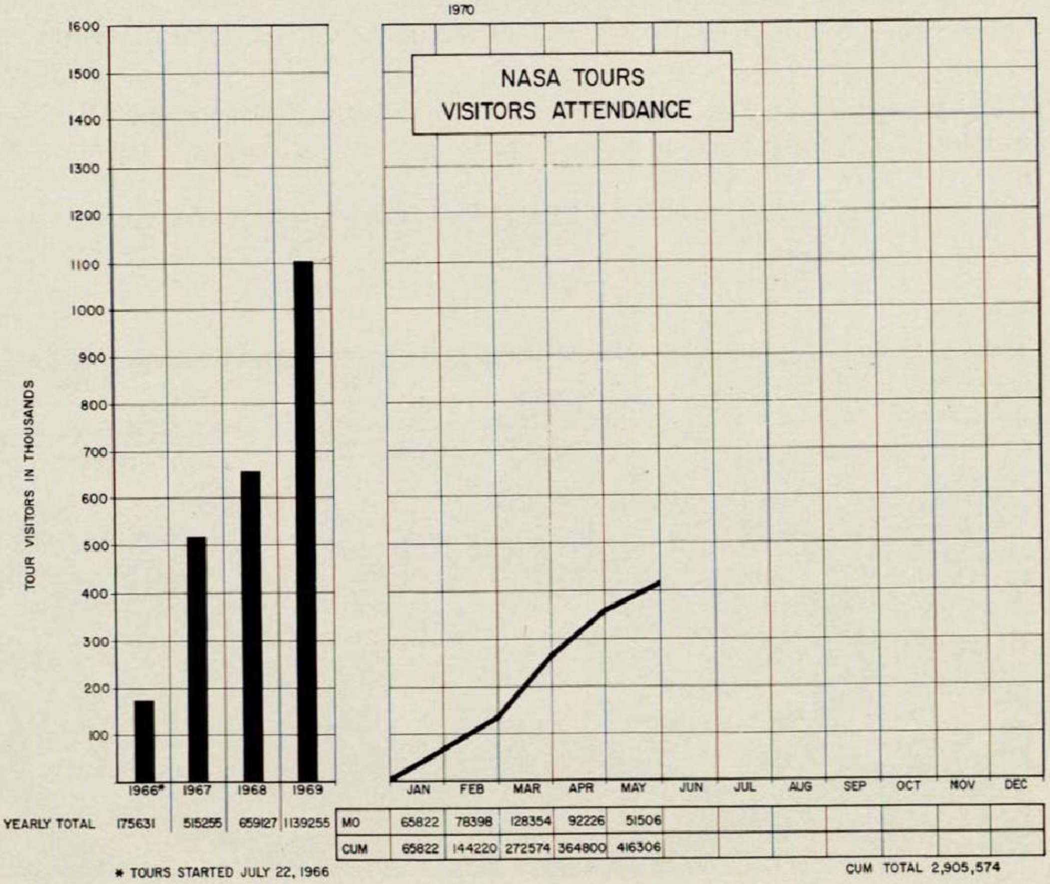
Dr. Robert C. Seamans, then Deputy NASA Administrator, and Julian Scheer, Assistant Adminstrator for Public Affairs, approved the Center's plans in April 1966. The Center contracted with Trans World Airlines, already providing base support services, to operate the tours. Work was begun on interim visitor facilities just outside the main

access gate and within half a mile of U.S. Highway 1. A small exhibit building, bus terminal, sanitary accommodations, snack bar, souvenir stand, and parking lot were provided by the Government. The first tours were scheduled for July 22, 1966.

It turned out to be a typical July Friday with heavy showers at intervals from midday on. Coincidentally, Congressman Teague and several members of his Subcommittee, including Congressman Edward Gurney (R-Fla.) who represented the District in which the Spaceport is located, were in the Center. Before leaving, they learned that 1,500 persons rode the buses the first day.

From July 22, 1966 through the end of the month, 18,576 admissions were counted. Attendance zoomed in August when 59,302 persons, 60 per cent of them adults, took the bus tours. Fifteen leased vehicles fur-

Steady increase has occurred in NASA Tours attendance at Kennedy Space Center since the program began in July 1966. Interest in Apollo missions accelerated the increase.



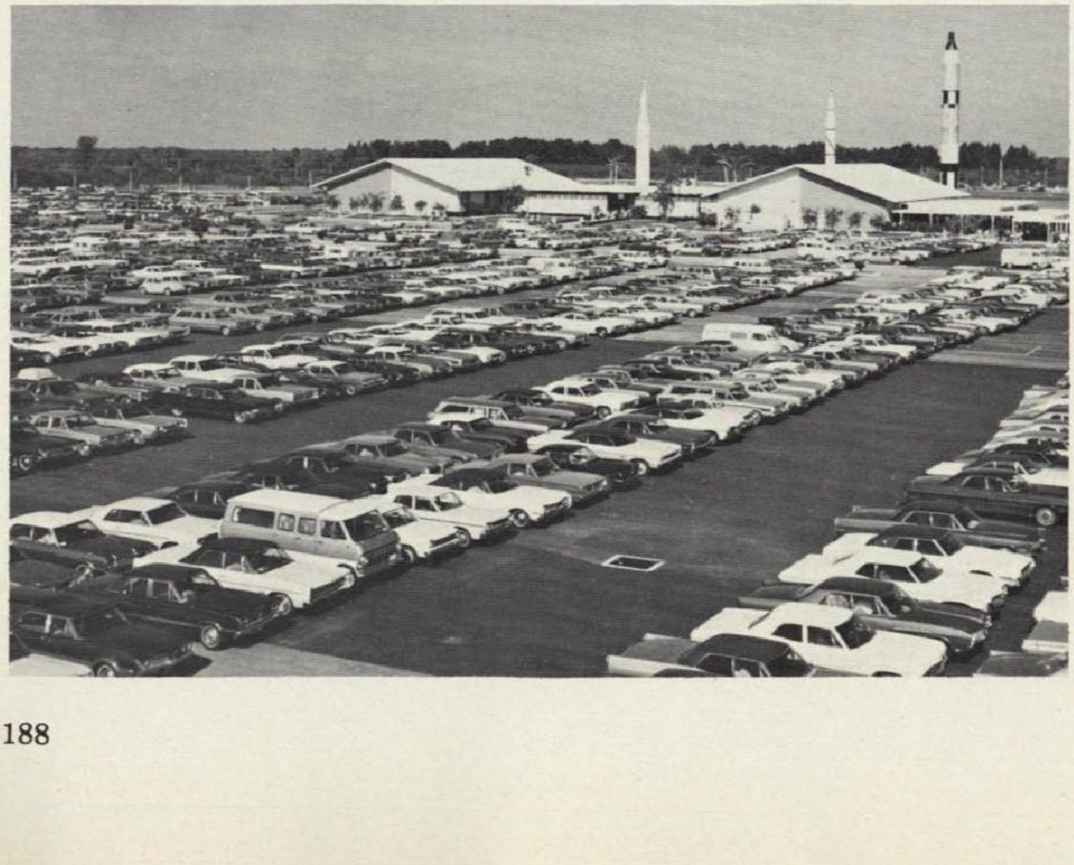
nished by the General Services Administration could not keep up with the influx and had to be supplemented by buses drawn from the NASA motor fleet. Even this combination proved inadequate on peak days.

Visitors saw buildings and launch complexes enroute. A glass enclosed viewing area was installed in the Vehicle Assembly Building transfer aisle, allowing visitors to see the interior. At times they also saw a giant Apollo/Saturn V on the launch pad, or a 6,000,000-pound crawler in motion, or a space vehicle ready for launch on Cape Kennedy. They enjoyed photographing the collection of military rockets displayed by the Air Force at Complex 26 and road signs marking the launch sites of Astronauts Glenn, Schirra, Grissom, Carpenter, Shepard and Cooper of Project Mercury, and the astronauts who flew Project Gemini missions in 1965 and 1966.

At Christmas season, attendance soared to a record of 4,300 per day. During the 1968 holiday season, attendance reached unprecedented proportions as 10,000 or more visitors arrived. By year's end 1,350,013 had participated in the daily tours since their inception. Meanwhile, the free Sunday drive-through tours continued and 194,120 others chose this alternative in 1968.

As the architect neared completion of plans for the Visitor Center, NASA became aware that increasing construction costs, the relatively high cost of site preparation and other contributing factors would pre-

During Christmas and other holidays the Visitor Information Center is overtaxed by daily arrival of thousands of tourists from all parts of the United States and Canada.



clude building a permanent structure within the $1,200,000 figure stipulated by Congress. So it was decided to prepare the site, install utilities, and erect interim structures of pre-fabricated type that would provide an equal amount of covered space, 20,000 square feet, called for in the Beckett design. It is hoped this will serve the need until 1970. By then, the Space Center will have acquired sufficient experience to determine how many people can be admitted daily and how best to accommodate them. Much as NASA wants to carry out its obligation to "inform and educate," as stated in the Space Act, the fact remains that the Center's primary mission is to conduct launches safely and successfully — all other considerations must be secondary to that objective.

The interim visitor facility has two auditoriums, each seating 240, where NASA shows motion pictures describing the national space program and the mission and operations of the Space Center. There are exhibits including a lunar module, Mercury, Gemini, and Apollo spacecraft, satellites and space probes. Approximately 1,150 cars can be parked in the paved area rear of the Visitor Center. Trans World Airlines and its subcontractor, Greyhound, increase the bus fleet as seasonal upturns occur.

Citizens of all 50 states and visitors from Latin and South America, Canada, Europe, Africa, the Middle East and Far East have taken the bus tours. In the first six months, more than 2,000 foreign visitors from 50 countries attended, including two who signed the register from a Moscow University. The signatures are voluntary.

TWA solicits visitor comments and suggestions. Most express their reaction in superlatives — "It makes me proud to be an American," "We pray for your success," or "The U.S. is making real progress." Some are critical either of the space program or the policy of charging fees for the tour. This, however, is an established policy of the Federal Government which requires the individual citizen to pay the cost of services rendered to him.

NASA planned the tour program would be operated on a no-profit no-loss basis so far as the Government's interest was concerned and insisted upon a high level of performance from its contractor. The fee schedule established in 1966 has been maintained at $2.50 for adults, $1.25 for teenagers and $.50 for children from 3 to 12 years of age. It was anticipated that income from the sale of souvenirs and snacks would help cover the operating costs. While the Government subsidized losses during the first year, the operation achieved a break-even point in 1967. In May, 1968, after a competitive procurement, TWA was awarded a concession type contract that can run up to 10 years. Greyhound became the subcontractor conducting the bus tours.

The public access program has enjoyed full support and cooperation of the Eastern Test Range which worked closely with the Space Center in selecting tour routes and stops utilized on Cape Kennedy. These must be changed periodically because of hazardous tests at various complexes, but by re-routing buses, the tour operator ensures that visitors see practically the same facilities and historic points of interest at all times.

Attendance has continued to increase. During 1968 the growth averaged 20 per cent compared to 1967. In December 1968, the launch of Apollo 8 to the Moon, and man's first close-up look at his nearest neighbor in space, spurred public interest. During Christmas holidays while Apollo 8 completed its mission, crowds of 10,000 jammed the Visitor Center daily. Tour attendance in January 1969 jumped 78 per cent over January 1968. The months of June, July and August, when tourism is at full flood, recorded increases of more than 100 per cent over the corresponding months a year earlier. Compared with 1968 patronage of 659,127 bus patrons, 1969 established a new record of 1,100,000.

A definite correlation became apparent as to the frequency of major launches and public visitation. Apollos 9, 10, 11 and 12 followed in quick succession during 1969. The intense public interest in each was undoubtedly reflected in the accelerated growth in bus tour activity. In 1970, when the Apollo launch rate slowed to two per year, the attendance grew more slowly and is expected to average 20 per cent. Meanwhile, the late December holidays of 1969 established more records when as many

Everett Sandusky of Mascoutah, Illinois became the 2,000,000th patron of NASA Tours on July 19, 1969. His wife and three daughters watch as he receives a memento of the occasion from A. F. Siepert, then KSC's Deputy Director for Management.

as 13,500 toured in one day. Visitor reaction continued highly favorable. More paved parking, a new service building, additional sanitary facilities, and improved bus loading and unloading platforms were added in 1969, paid for by tour income.

A complementary project was inaugurated as schools reopened for the Fall term in 1966. The Center decided to augment the tour program by satisfying the special requirements of students. A minimum rate of $.50 was fixed for those under 12 years of age while students over 12 paid $1.00. The fees are less than transportation cost, but it was reasoned that other tour income would supplement the bargain rates. When accompanied by teachers and traveling in class groups, students also hear a space science lecture of 45 minutes. The lecturer instructs the class in space technology, employing rocket and spacecraft models, film and slides.

The Center's Educational Programs Branch, directed by William Nixon, announced the plan to educational institutions of Florida, Georgia, Puerto Rico and the Virgin Islands. The first student tour was conducted October 1, 1966. Classes arrived from nearby communities at first, traveling in bright yellow school buses. Always in high spirits, the children boarded TWA's air conditioned buses and embarked on tour after hearing the lecture. In the first month 974 students came from Florida schools. Since then well over 150,000 students and teachers have attended the lectures. Reservations in 1970 reflect a steady increase.

YEAR	STUDENTS	SCHOOLS
1966*	5,444	60
1967	25,496	321
1968	30,156	377
1969	42,652	610
1970**	30,353	418

* October-December 1966
**January-May 1970

Classes come from points as far distant as Indiana and Texas. It is not unlikely that for schools in the Southeast, the annual pilgrimage to the Spaceport may become as popular as the traditional graduation trip to the Nation's Capitol.

Early in 1970, Senator Edward Gurney (R., Fla.) appeared before the Committee on Aeronautical and Space Sciences of the U.S. Senate and urged Congressional assistance to the Space Center's public access program. Senator Gurney recommended an addition of $2,000,000 to NASA's FY 1971 budget in order to enlarge the people handling capabilities of the Visitor Information Center which, he said, are severely overtaxed in peak periods. Meanwhile, Dr. Debus put his staff to work on planning a larger and permanent facility in which space technology, the

accomplishments of space exploration, and its future promise can be presented to the bigger audiences confidently expected.

There is concern about the number of visitors who may come in 1972 and subsequent years. The Disney interests will open a new project in October 1971, south of Orlando, and about one hour's drive from the Space Center. They forecast first year attendance of 8,000,000. The combination of a Disney attraction 50 miles to the west of KSC may elicit so heavy a response that NASA will be compelled to place constraints on the numbers which can be admitted in any one day. NASA anticipates 3,000,000 visitors in 1972 and believes the attendance will increase to 5,000,000 annually during the next five years.

Tours are not the only measure of public interest in space. As do other NASA centers, KSC receives a steady volume of mail, from 4,000 to 5,000 letters monthly, from children, young people and adults. The writers are chiefly U.S. citizens but some letters come from other Free World nations, and a few reach the Spaceport from Czechoslovakia, Romania, Yugoslavia and other Communist states. They seek information, they offer suggestions, they ask for photographs, and they sometimes enclose small contributions to help pay for space flights. These are returned with the agency's sincere "thanks."

Tour patrons see the Mission Control Center exactly as it was configured for Mercury launches.

XX

Distinguished Visitors

THE basic policies expressed in the Space Act of 1958, which established the national space program, had far-reaching consequences, the ultimate results of which defy measurement.

The first was to dedicate the program to the acquisition of new knowledge for peaceful purposes. The clear intent was to share this knowledge with men of good will. That objective was stated by President Eisenhower, by President Kennedy, by President Johnson and President Nixon. Mr. Johnson transmitted to the heads of 100 nations the first close-up photographs of the Moon taken by a Ranger spacecraft. Mr. Nixon addressed the United Nations in September 1969, and pledged cooperation in space research. NASA has consistently released new information gleaned from scientific observations with many other countries including the Soviet Union. In turn, Soviet scientists distribute data derived by some of their spacecraft.

NASA has pursued the second policy successfully in all launch operations. They are conducted in public. They are witnessed by the press who are also free to visit NASA research centers. By radio, television and wire, the press transmits detailed, on-the-spot reports of manned flights from liftoff until the astronauts have safely returned. The press also reports unmanned missions conducted by the agency, although these do not enjoy as much coverage as the manned launches. The same, open-door policy applies to those launches which NASA conducts for the Communications Satellite Corporation, the Environmental Science Services Administration, which operates weather satellites, and scientific satellites placed in orbit for other nations including the United Kingdom, Canada, France and Germany.

This evident willingness to share has earned the admiration and respect of the Free World. The ruling heads of friendly nations, their ambassadors and other official representatives have commended the open

policy during frequent visits to the Kennedy Space Center in which they evince keen interest in the U.S. program.

President Kennedy maintained lively personal interest in Saturn development and the construction of the Spaceport. He visited the Center for the last time November 16, 1963, just six days before his tragic death, flying over the base with Dr. Debus in a helicopter. He saw the work then in progress and preparations for launching a Saturn I vehicle, the first to carry a live, hydrogen-fueled second stage. In recognition of the slain President's contribution to space exploration, President Johnson changed the name of Cape Canaveral to Cape Kennedy November 28, 1963 and designated the total launch facilities the Kennedy Space Center.

Dr. Debus and former Administrator James Webb greeted President John F. Kennedy as he arrived at the Center.

Presidents Kennedy, Johnson and Nixon invited leaders of other nations to see the launch base. While Apollo/Saturn V launch facilities were in construction, they were seen by the President of India, the Shah of Iran, the Prime Minister of Israel, the King of Jordan, the King and Queen of Afghanistan and the Grand Duchess of Luxembourg. Dr. Debus and his charming wife, Mrs. Gay Debus, are hosts for NASA on these occasions. Mrs. Debus pays close attention to the arrangements for social affairs such as luncheons and dinners. R. E. Johnson, the KSC protocol chief, works closely with the Department of State in arranging the itineraries.

All four Presidents since 1958 visited the Center. President Johnson dropped in for a quick tour September 15, 1964, after speaking to a labor

Dr. Debus briefed President Lyndon B. Johnson in the Launch Control Center of Complex 34 during a tour. Former Deputy NASA Administrator Robert C. Seamans, now Secretary of the Air Force, is at right.

convention in Miami. His 90-minute visit included a stop at Launch Complex 37 where a Saturn rocket was undergoing pre-flight test, and in the NASA laboratories on Cape Kennedy where a Mariner spacecraft was being prepared for flight to Mars. The President enjoyed donning a white gown and cap like those worn by surgeons and running his shoes through a cleansing machine — these precautionary measures designed to prevent contamination of the satellite. NASA Administrator James Webb escorted the Presidential party.

Since there had been very little time to prepare for Mr. Johnson's visit, the Center encountered a touchy problem. Shortly before his arrival, someone noted that the sedan driven by the Secret Service would accommodate only two passengers. Phone calls to auto dealers, funeral directors and rental agencies failed to locate a seven-passenger sedan in the vicinity. Someone recalled that Mrs. Evelyn Stewart, a resident of Merritt Island, owned such a car. She promptly agreed to loan it to the Center. It was speedily washed, inspected and pronounced acceptable by the security detail. The car reached the airstrip 15 minutes before the Presidential jet touched down.

NASA returned the car to Mrs. Stewart after the President left, and gave her a model of the Saturn vehicle in recognition of her assistance. She confirmed her generosity to the press, commenting that she

Assistant Secretary of Labor William Usery, at left, chats with Florida's Governor Claude Kirk awaiting launch of Apollo/Saturn V space vehicle.

didn't agree with President Johnson when he changed the name of Cape Canaveral. And Mrs. Stewart pointed out that plainly visible on the front bumper of her sedan was a metal plate reading "Cape Canaveral, Florida." In effect, she had the last word.

President Johnson returned September 27, 1966 with Chancellor Ludwig Erhard of West Germany, Secretary of Defense Robert McNamara, Administrator Webb and U.S. and German diplomats. They visited the Gemini launch complex, received a briefing from Astronaut James Lovell, and inspected the Apollo Saturn V facilities at Complex 39 which were nearing operational status. Dr. Debus found himself seated between the President and the German Chancellor during the tour, acting as interpreter as the two leaders carried on lively conversation.

In the Vehicle Assembly Building, President Johnson spoke to several thousand KSC employees, reiterating his belief that the space program would benefit mankind and become an instrument of peace.

The President said:

"I wanted Chancellor Erhard to see what you are doing here, not merely because of the pride we take in what you are achieving, but also

King Baudouin and Queen Fabiola of Belgium visited the Center to view the Apollo 10 launch. Here Vice President Spiro T. Agnew talks with the King during a luncheon in his honor.

because of the promise which this great Spaceport holds for the future of mankind. The story of man's achievement throughout history has been the story of his victory over the forces of nature. In that continuing story, our generation has been given the opportunity to write the grandest chapter of them all. Much of that chapter has already been written in this place.

"It has been said that the real and legitimate goal of science is the endowment of human life with new invention and riches. That is the real goal of our space effort. The benefits of our achievements must flow not just to a single nation, but they must flow to all nations and to all people."

Vice President Hubert Humphrey came to the Center first in February 1965. By virtue of his office he also served as chairman of the Na-

Mrs. Debus with former President and Mrs. Lyndon B. Johnson in viewing stands near the Vehicle Assembly Building to view the launch of Apollo 11.

tional Aeronautics and Space Council. So had Mr. Johnson while in the Vice President's office. So, too, does Vice President Agnew function in the Nixon administration. Mr. Humphrey came back March 23, 1965 to witness the first Gemini launch of Astronauts Virgil Grissom and John Young. At the time, he was the highest ranking U.S. official to attend a manned launch. President Nixon witnessed the Apollo 12 launch in November 1969.

During 1965 the Center entertained Crown Prince Bertil of Sweden, and Chung Hee Park, President of the Republic of Korea. Gemini launches in 1966 inspired many visits by U.S. and foreign dignitaries including Cardinal Conway of Ireland and Cardinal Seper of Yugoslavia. During an impromptu talk to the Gemini launch team, Cardinal Conway said that in every Irish cottage, the people followed the progress of the U.S. space program and prayed for safe return of the astronauts. "It's our program as well as yours," the Cardinal commented.

President and Mrs. Richard M. Nixon and daughter, Tricia (foreground), viewed the launch of Apollo 12. NASA Administrator Dr. Thomas O. Paine shields President and Mrs. Nixon from rain.

When Gemini IX was to be launched in May 1966, the Chief Justice of the U.S. Supreme Court, Earl Warren, arrived with U.S. Senator Clinton Anderson, chairman of the Senate Space Committee, and NASA Administrator Webb. The launch had to be postponed, but the flight crew, Astronauts Tom Stafford and Eugene Cernan, greeted Justice Warren and Senator Anderson. The mission was successfully launched four days later.

Sixty-three Ambassadors or Chiefs of Mission, representing the Washington diplomatic corps, arrived in a Presidential jet December 4, 1965 to witness the launch of Gemini VII with Astronauts Frank Borman and James Lovell. They lunched in the cafeteria of Complex 39 where the senior diplomat, Belgian Ambassador Baron Louis Scheyven, thanked his hosts with the observation that "only in the United States of America could the representatives of 42 sovereign nations be privileged to observe what we have seen today."

Among the nations represented were the Republic of Upper Volta, Cyprus, the Malagasy Republic, Senegal, Dahomey, New Zealand, Italy, India, Laos, Liberia, Greece, Costa Rica, Turkey, Malaysia, Jamaica, Yugoslavia, Guinea, Japan, Yemen, Gabon, Norway, Uruguay, Peru, Sweden, Portugal, Tunisia, Iraq, Spain, Rwanda, Mauritania, Chad, the Netherlands, Luxembourg, Argentina, Niger, Australia, Togo, Uganda, Nepal, Mali, Zambia, Korea, Central Africa, Mexico, Finland, South

Following the Apollo 12 launch, President and Mrs. Nixon visited the LCC firing room where he addressed the Government-contractor launch team. Left to right (foreground) are Dr. Debus, President and Mrs. Nixon and Launch Operations Director Walter Kapryan.

Africa, Chile, Denmark, Indonesia, Sudan, Bolivia, Malawi, Burma, Somali, Iceland, Ethiopia, Morocco, Nigeria, Jordan, Syria, Dominican Republic, Tanzania, France, Lebanon, Congo, Burundi, El Salvador, Cameroon, Pakistan, Ecuador, Paraguay, Nicaragua, Saudi Arabia, Ghana, Israel and Lithuania.

Representatives of the United National Commission on the Peaceful Uses of Outer Space were guests of NASA and the State Department for the final Gemini mission flown by Astronauts Lovell and Aldrin November 11, 1966. Dr. Ralph Bunche, Under Secretary for Political Affairs, wished the departing crew Godspeed. They invited Dr. Bunche to join them, but he declined with a quick smile. With the U. N. group were the Ambassadors of Argentina, Australia, France, Iran, Italy, Morocco, Poland, Romania and the Philippines.

President Johnson invited Soviet scientists to witness a Gemini launch, but the Russians declined. President Nixon later invited the Soviet ambassador, as well as other foreign representatives in the U.S.,

Dr. and Mrs. Debus (right) were hosts to President and Mrs. Georges Pompidou of France on February 26, 1970. President Pompidou inspects treads of the Crawler at Complex 39 as Mrs. Pompidou listens to Dr. Debus' explanation of its operation.

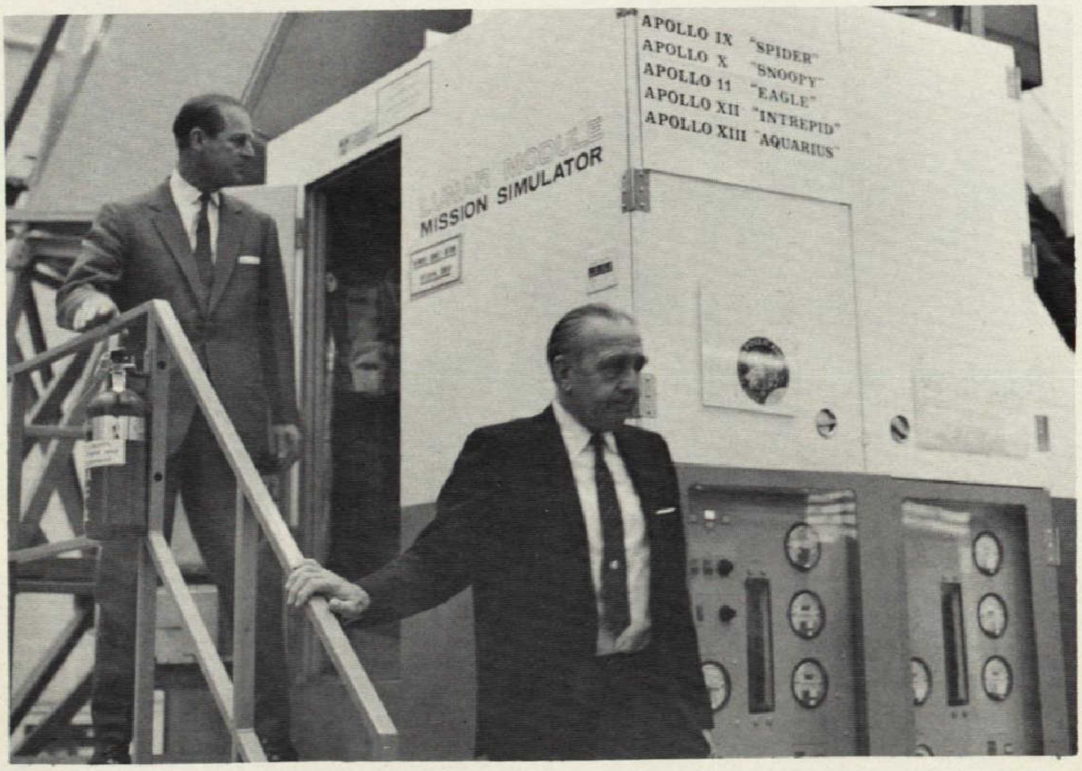
to the launch of Apollo 11. He also declined.

Distinguished visitors continued to arrive in 1967. President-elect Arthur da Costa e Silva of Brazil toured in January with Florida's new Governor, Claude Kirk. President Cevdet Sunay of Turkey arrived in April followed a month later by C. K. Yen, Vice President of China. The Center hosted Lord Richard Gardiner Casey, Governor General of Australia; Lord Richard Coleridge, executive secretary of the North Atlantic Council; the King and Queen of Nepal, the Crown Prince of Laos and the Foreign Minister of Pakistan.

Many Senators and Congressmen came to view the construction progress for the future Apollo launches to the moon. One Congressman encountered an unexpected hazard. His sedan approached a puddle which straddled the makeshift road. The driver noted tracks which indicated another vehicle had crossed safely, so he drove into the puddle. The car began to sink. As the interior rapidly filled with water, the Congressman perched atop the back seat and waited, in patient but damp dignity, until another vehicle rescued him.

Industrialists, scientists and educators are among the Center's thousands of visitors. A steelmaker looked about the framework of the Ve-

Prince Philip of Great Britain visited KSC February 14, 1970. Here he follows Dr. Debus from Lunar Module Simulator in Astronaut Training Facility.



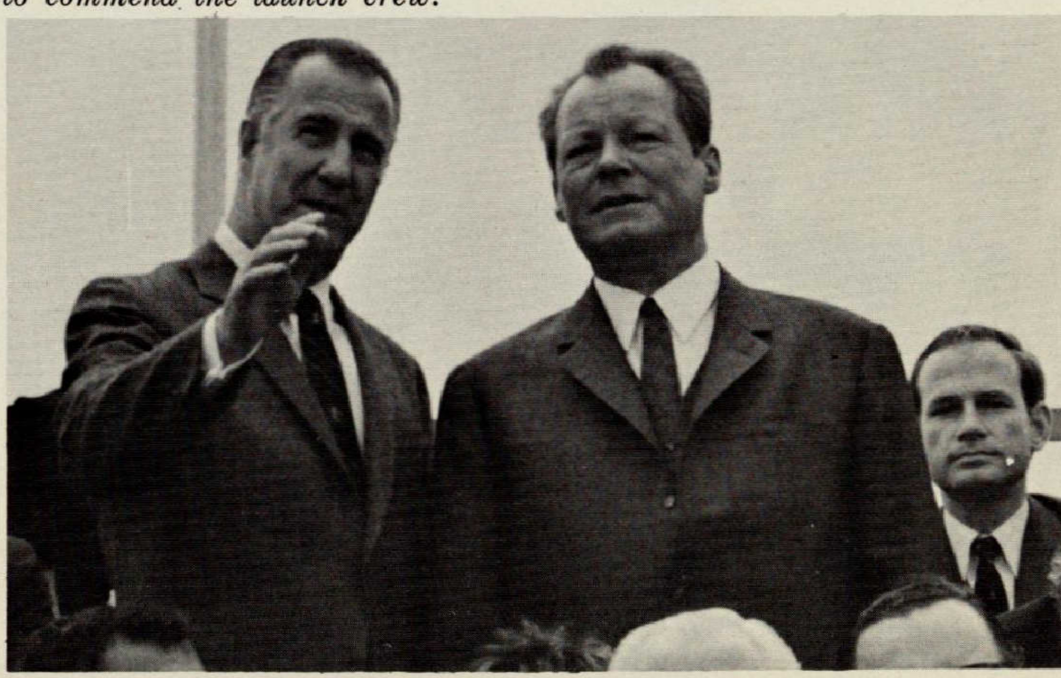
hicle Assembly Building and observed that "You have more steel than we have in Pittsburgh."

Highlighting the 1968 visitations was a tour November 24 for Mrs. Lyndon B. Johnson and her daughter, Mrs. Charles S. Robb. This was Mrs. Johnson's first opportunity to see the Spaceport, one of the major installations of the space program which President Johnson helped construct. She was accompanied by Astronauts Walter Cunningham and John Young as she examined Gemini, Apollo and lunar spacecraft. With the help of the astronauts, she piloted the lunar simulator to a safe landing on the Moon. Mrs. Johnson was greatly impressed as Dr. Debus explained the potential of space-borne instruments to measure the health and growth of crops and forests, the status of water reserves, and the presence of mineral and oil deposits. Aware of the mounting concern worldwide over Earth's expanding population and the problem of feeding more millions in generations to come, Mrs. Johnson clearly grasped the possible application of satellite systems for the effective management of food resources.

King Olav V of Norway; the Prime Minister of Mauritius, Seewoosagar Ramgoolam; the Prime Minister of Swaziland, Prince Makhosimi Dlamini; the Prime Minister of New Zealand, Keith Holyoake; the President of Chad, Francois Tombalbaye; the Amir of Kuwait, Shaikh Sabah al-Salim al-Sabah and the President of Honduras, Oswaldo Lopez Arellano, toured KSC during 1968.

The launch of Apollo 8 December 21, 1968 brought out the largest

West German Chancellor Willy Brandt viewed the Apollo 13 launch with Vice President Spiro T. Agnew. He later visited the LCC firing room to commend the launch crew.



collection of notables to date, including Governor Kirk of Florida, Governor-elect Preston Smith of Texas, U.S. Senators Frank Moss, Edward Kennedy and Ralph Yarborough, with 30 Members of the Congress; Supreme Court Justices Potter Stewart and William J. Brennan, Jr.; Secretary of Agriculture Orville Freeman, 76 members of the Washington diplomatic corps, the presidents of Lions, Kiwanis, and Toastmasters International; the commanders of the American Legion and AMVETS, and leaders of organized labor, industry and science.

Vice President Spiro Agnew visited KSC for the first time to see the launch of Apollo 9 March 3, 1969. Three thousand other distinguished guests also attended. The Vice President returned for Apollo 10 and dined with the astronauts and Dr. Paine the evening before launch. Approximately 3,500 guests crowded the viewing site as the Saturn V lifted off the pad to carry Astronauts Tom Stafford, Gene Cernan and John Young to the Moon.

Apollo 10's success spurred planning for the record attendance which would mark the next launch, the first attempt to land on the Moon. Five guest centers were set up in Cocoa Beach, Melbourne, Titusville, Daytona Beach and Orlando to accommodate 5,429 guests. Normal visitor staffing was supplemented by personnel from other NASA field activities and

U.S. Senator Edward J. Gurney, Florida, an avid supporter of the U.S. space program, is shown with Mrs. Gurney as they awaited the launch of Apollo 10.

from KSC line and staff elements. A fleet of 183 buses was employed for pre-launch tours provided to the guests, and to transport them to and from the viewing site July 16, 1969. The Eastern Test Range coordinated arrivals and departures of 21 jet aircraft bringing in guests who landed at Patrick Air Force Base and the Cape Kennedy Skid Strip the morning of the launch.

Vice President Agnew brought with him 14 Governors and the Mayors of several of the nation's largest cities. President Nixon invited former President Johnson and Mrs. Johnson. Fifty-six ambassadors, two foreign ministers, 11 science ministers, 62 air attaches, 128 Korean parliamentarians, 225 French industrialists, scientists and journalists were on hand. LIFE Magazine sponsored a flight from New York City for 50 corporate presidents. Jack Benny and Johnny Carson, television performers, shared the spotlight with Governor Kirk, diplomats, educators, and 249 members of the U.S. Senate and the Congress.

The President and Mrs. Nixon visited the Spaceport for the November 14, 1969 launch of Apollo 12. It was the first time a President attended a manned launch. Weather conditions were far from ideal. Rain fell intermittently through the night, ceased at times during the morning hours, and resumed shortly before the launch when the Presidential helicopter sat down in water-soaked grass at the viewing site for dis-

During a 1970 visit of Hon. Olin E. Teague, Texas, Chairman of the House Sub-committee on Manned Space Flight, Dr. Debus presented him with a gavel fashioned of wood from a shock absorber used on holddown arms on a mobile launcher.

tinguished guests. Seats had been reserved for President Nixon and his party in bleachers where their arrival was awaited by young people representing such national organizations as Boy Scouts, Girl Scouts, Camp Fire Girls, 4-H Clubs, Future Farmers, Future Homemakers, and Girls Clubs of America. At Mr. Nixon's side was Dr. Thomas O. Paine, NASA Administrator, and Col. Frank Borman, who commanded Apollo 8. Mrs. Agnew sat in the stands while the Vice President occupied his favorite position in an observation area within the Firing Room.

Among the 3,000 guests in the bleachers were Secretary of Transportation John Volpe; the Aga Khan, Henry A. Kissinger, the President's assistant; Mrs. Helen Bentley, chairman of the Federal Maritime Commission; Dean Burch, chairman, Federal Communications Commission; Dr. T. J. Thompson of the Atomic Energy Commission; Father Theodore M. Hesburgh, president, Notre Dame University; Paul Miller, president, the Associated Press; Senator Edward Gurney, Florida; Chairman George P. Miller of the House Space Committee; Chairman Olin E. Teague of the Manned Flight Subcommittee and Congressmen Earl Cabell, Texas; Emilio Daddario, Connecticut; Robert Price, Texas; Benjamin Blackburn, Georgia; J. Herbert Burke, Bill Chappell and William Cramer, Florida; Clarence Miller, Ohio; Rogers Morton, Maryland and Claude Pepper, Florida.

KSC Deputy Director Miles Ross and Dr. Eberhard Rees (right), Director of the Marshall Space Flight Center, view an Apollo rollout at Complex 39.

Following launch, President and Mrs. Nixon drove to the Firing Room where they were greeted by Vice President Agnew, Dr. Debus and other NASA officials. Standing before the assembled launch team, the President described his feelings in these words: *"Here is the sense of not just the sight and the picture, but a feeling of awe. Except for what you are doing here, the astronauts couldn't be there, and they would not make this mission successful. Every one of the astronauts, when they come to the White House, make the point that those on the ground, engineers, technicians, scientists and all who work in the program, are really the heart of this great, successful experience for the American people and for all the people of the world.*

"We are going forward. America is first in space. We're proud to be first in space. We want to give the people, particularly our young people, the feeling that here is an area on which we can concentrate for a positive goal and be proud of being Americans. The nation owes you a debt of gratitude, and as President of the United States, I express that debt and acknowledge it today."

In February 1970, Britain's Prince Philip toured with Dr. Debus and flew a lunar landing in the simulator with Astronaut John Young. Later in the month President Pompidou of France saw the Saturn V which would carry the Apollo 13 astronauts. He also piloted the lunar simulator with Young.

When NASA launched the Apollo 13 mission April 11, 1970, Vice President Agnew returned with Chancellor Willy Brandt of the Federal German Republic. Again, members of the Congress, leading figures of

Hon. Lou Frey, Florida, member of the House Sub-committee on Manned Space Flight, is shown during a tour with KSC officials. Left to right: Congressman Frey, Walter P. Murphy, Director of Executive Staff; Harold R. Pyles, Support Operations, who briefed the group; Frank Daley, administrative assistant to Congressman Frey; and Raymond L. Clark, Director of Technical Support.

the scientific, industrial and educational communities gathered at the site to observe the liftoff. The number of guests ran close to the record throng invited for Apollo 11. More than 5,000 were in the bleachers or watching from the grassy infield as the Saturn V flamed into life exactly on schedule on a warm, sunny afternoon. As the rocket began its journey, the Vice President escorted Chancellor Brandt to the Firing Room where both officials spoke to the launch team, once again praising the superb teamwork demonstrated to the entire world. Later, he entered the simulator with Astronaut David Scott who also took Mrs. Brandt and Mrs. Debus into the device. The astronauts and the simulator manager, Riley McCafferty, arranged a surprise for their guests. When the French President steered the module towards a touchdown, the Eiffel Tower appeared on the lunarscape. For Chancellor Brandt, the surprise was the familiar symbol of Volkswagen.

The launch base will continue to attract the world's most famous personages as more manned launches continue to the Moon and as NASA plans to fly manned laboratories into orbit and probe the planets, seeking to unlock the secrets of the Universe and perhaps one day finding other forms of life in outer space.

Some of the 5,429 guests who viewed the launch of Apollo 11 near VAB.

XXI

Serving The Press

TODAY'S "open door" policy by which the press covers Cape Kennedy launches has sharply reversed the Government's firm position during the 1950s. Army, Air Force and Navy rockets flown from the Cape in that decade were considered so important to national defense that even the shape of the rocket, as well as its performance, was secret. No one outside the Military Establishment, especially news hungry reporters, was supposed to know the date and time of launch, what would be tested or what happened after the rocket left the pad.

A security wall protected the proving ground, occasionally penetrated by loose talk, and was so tightly enforced that even the wives of the Secretary of Defense or the Secretary of the Army were not admitted to the Cape. Rumors dropped in cocktail bars or service stations were avidly snapped up by the press who stood watch on Cocoa Beach or along the jetties of Port Canaveral for hours on end, hoping to glimpse a departing rocket or witness its fiery death.

The military provided terse announcements after launchings, usually stating only that a rocket had been fired successfully, or that it was a partial success, or a failure.

A completely novel approach in the handling of public information had been instituted in connection with Project Vanguard which began in 1956 as a national undertaking to place in Earth orbit an eight-pound, ball-shaped satellite. This was part of the United States participation in the International Geophysical Year, a world-wide study of space phenomena in which the Soviet Union and other countries took part. The Naval Research Laboratory was assigned to develop the carrier rocket, as well as the satellite. Since the program was non-military, by definition and objectives, detailed descriptions of the rocket, the satellite and the Earth tracking network with which it would communicate were released to the press.

Following the appearance of the first Sputnik, the press was invited to witness the first attempt to launch Vanguard December 6, 1957. For the first time reporters and television and radio commentators received thorough briefings and were taken to a raised area on Cape Kennedy where communications were installed to permit direct, on-the-spot news coverage. Vanguard rose several feet, slowly settled back and exploded in a burst of flame while millions watched and listened, hoping for success that would restore some of the shaken confidence left in the wake of the Soviet achievement.

Reaction to the failure was immediate and profound. While some critical voices were raised against the publicity showered on the smouldering launch scene, a precedent had been established that could not be erased. The Defense Department accepted proposals from leading figures in the communications industry to change the policy and worked out a solution which became the procedure for several years. The Commanding General of the Atlantic Missile Range, as it was known, Major General Donald Yates, USAF, met the press regularly, told them what launches were scheduled over the next several weeks, and arranged for reporters to witness any but classified military operations from the Cape press site. On their part, the resident press corps agreed not to publish information about launches in advance, to report only when "fire appears in the tail," and not to comment on postponements. As to the rocket's performance in flight, the press still depended upon the military for information, understanding that genuinely secret details would not be disclosed.

This was the arrangement as the Army Ballistic Missile Agency commanded by Major General J. B. Medaris prepared for the second U.S. attempt to launch a satellite, employing the Jupiter C rocket, developed by Dr. von Braun and his group and previously tested with complete success. Canvas shrouds were hung from the service structure to conceal the shape of the vehicle since it was generally believed the status of the United States as a world power would be adversely affected if another failure occurred. Some guarded, brief items appeared in the press as launch day neared but little was known about the rocket or its satellite. On January 31, 1958 the Jupiter C roared off into the night performing flawlessly, and 90 minutes later President Eisenhower announced that Explorer I had achieved orbit.

With the advent of NASA later in the year, the "open door" policy was further liberalized. It reached a new level when the Project Mercury manned launches occurred. Every detail of preparations received saturation coverage by television, radio, motion pictures and the press. Lt. Col. John A. "Shorty" Powers, on detail to NASA from the Air Force, became world famous as the official "Voice of Mercury." For the coverage of

Gemini launches in 1965 and 1966, however, the media expended still greater effort. The television networks estimated they invested approximately $1,000,000 per launch. John W., or Jack King, as he is better known, became NASA commentator at the Cape, turning over the commentary to Paul Haney of the Manned Spacecraft Center after the vehicle lifted from the launch pad.

The initial manned Gemini flight March 23, 1965 attracted 780 accredited newsmen to Cape Kennedy, most of whom stayed on for the recovery and return of the pilots. As control of the missions shifted to the Manned Spacecraft Center, the media divided their manpower between Cape Kennedy and Houston, Texas. Thus when Gemini VII was launched December 18, 1965, 430 reporters were accredited to the launch site and for the final Gemini XII mission in November 1966, about 400 newsmen operated here. To accommodate them, as well as providing assistance to newsmen covering other NASA launches, the agency maintained an information center in Cocoa Beach and staffed the press site on the Cape as well. The Air Force provides buses and escorts in support of NASA launch activities when the press coverage occurs on the Cape.

Except for an occasional classified operation, such as a Polaris rocket fired from a submarine off the coast, the military adhere to a news policy similar to that of NASA. The Air Force admits the press to cover the events from the same vantage point on the Cape which is equipped with telephones and other communications facilities. The television and radio industry installed a switching central which transmits voice and video signal via commercial lines to New York City. Networks maintain studio-type trailers from which such well-known commentators as Walter Cronkite for the Columbia Broadcasting System, David Brinkley for National Broadcasting Company and Jules Bergman for the American Broadcasting Company tell their viewers what happens during the launch.

NASA's Assistant Administrator for Public Affairs, Julian Scheer, coordinates the press arrangements at both the Kennedy and Manned Spacecraft Centers from liftoff through recovery and return of the astronaut crews. Detailed information plans are formulated in advance by NASA which brings to the launch center experienced information staffs from the Headquarters and other NASA installations to assist in serving the needs of the press corps.

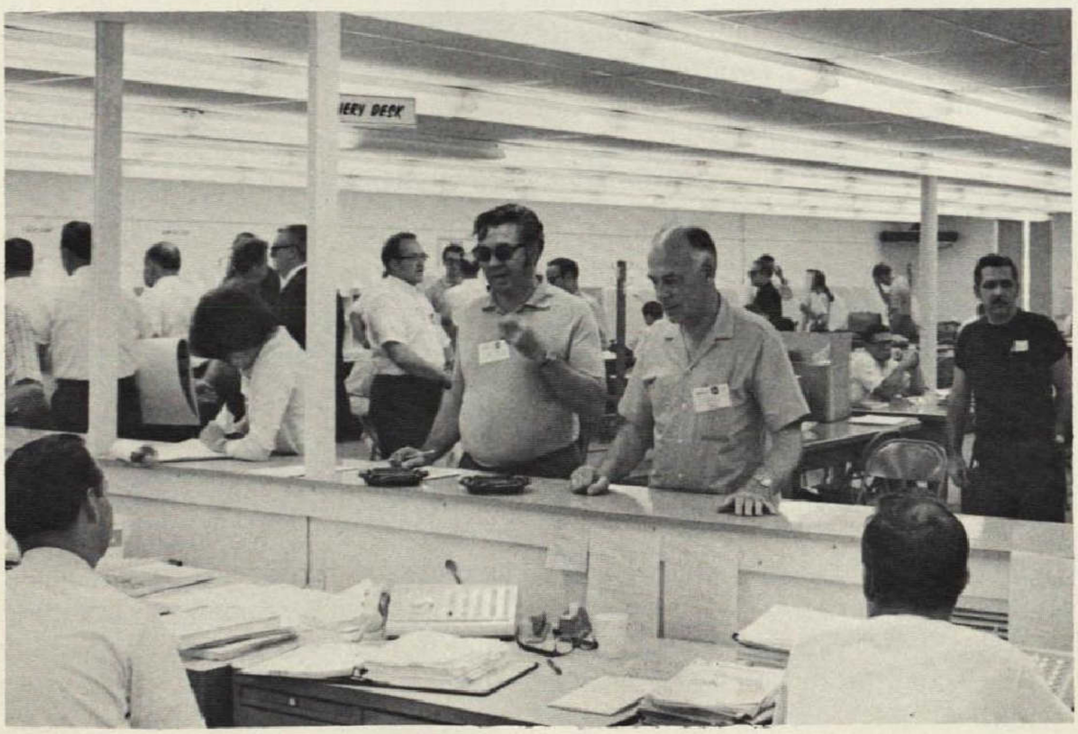
The U.S. Information Agency covers launches in much the same fashion as commercial media and transmits to overseas centers photographs and text for distribution to foreign media. Some foreign news services such as Agence France Presse and Reuters assigns correspondents to the Cape. So do some of the larger foreign dailies, radio and television organizations.

Foreign newsmen visit the Space Center throughout the year to photograph facilities and interpret for their audiences the progress of the U.S. space program. Manned launches receive more attention because of their inherent drama than do the unmanned scientific spacecraft launched by NASA. They command front page space in the United Kingdom and Europe, the Far East and Middle East even as they do in the United States. What transpires at Cape Kennedy receives worldwide exposure, such is the magnetic attraction of space exploration.

Preparing for the anticipated influx of newsmen who cover the Project Apollo three-man flights, NASA began construction of a press facility at Complex 39 in 1966 and completed the work before the launch of Apollo 4 in November 1967. A covered stand provides seats, writing counters and telephones for 350 reporters. Arrayed next to the stand on the elevated press site are the studio trailers of the television and radio networks and local radio stations. The site affords a commanding view of the Vehicle Assembly Building, the Launch Control Center, and both Saturn V launch pads.

The November 9, 1967 launch of the first Saturn V marked the initial use of the press site facilities. NASA accredited 510 media representatives and contractors for access to the site and among them were

Inquiry desk at Apollo News Center where 3,497 media representatives reported in to cover the launch of Apollo 11.



reporters who are veterans of the space program, accustomed to the tension which builds up as the countdown nears zero and the burst of flame signals ignition of the rocket engines. No one, however, had ever seen a rocket of the proportions of Saturn V waiting majestically three and a half miles to the east on Pad A. Except for measurements taken during static testing of the first stage at Huntsville, Alabama months before, no one had ever heard the noise its five 1,500,000-pound thrust engines would generate.

But if there were unknowns in the situation, every writer and commentator fully appreciated the significance of the event because if Saturn V performed as designed, the United States would have available a powerful vehicle capable of transporting 240 tons into Earth orbit as well as hurling 45 tons to the Moon. So, inevitably, there was a keen sense of anticipation and not a little anxiety as the countdown steadily proceeded towards the scheduled 7 A.M. firing.

Walter Cronkite, the Columbia Broadcasting System's ace newsman, watched intently through a plate glass window in his trailer. He saw the enormous burst of flame as ignition occurred. Then, as the Saturn V began to lift from the mobile launcher deck, the tremendous air pressure generated by its engines shook the trailer violently. His audience heard

Newsmen file stories from News Center press room.

Cronkite exclaim: "The building is shaking. Oh, it's terrific. We're holding the glass wall with our hands. The roar is terrific. Look at that rocket going, look at it going! Part of the roof has come in here." Later he commented, "this is absolutely unbelievable — next time we need a blockhouse, not a cottage."

Press photographers argued before launch that they should be allowed to take up positions within the hazard zone and closer to the rocket. But their minds were quickly changed as their bodies and ears felt the tremendous power of the Saturn V. Later, NASA engineers reported the sound level at the press site ranged from 123 to 126 decibels, below the threshold of pain but of sufficient intensity to satisfy even the press.

Media attention on a national level turned to the Space Center again in October 1968 as the launch team prepared a Saturn IB vehicle and the Apollo 7 spacecraft for the first manned launch since Gemini XII in November 1966. The crew selected for this Earth orbital 10-day mission, Walter Schirra, Walter Cunningham and Donn Eisele, had followed closely the assembly and testing of the Apollo in the North American Rockwell plant in Downey, California, and the subsequent checkout and testing in the Kennedy Space Center's altitude chambers, while undergoing rigorous simulator training themselves. Because this would signal the resumption of manned flights and would be the initial manned Apollo mission, press interest steadily increased as launch time drew nearer. The NASA News Center accredited 723 newsmen who were to see the event from their working site on Cape Kennedy, less than two miles from Launch Complex 34.

They watched the 220-foot vehicle lift from its pad exactly on time, at 7 A.M., reported its perfect boost performance, and thereafter kept the public informed as the crew put this modified spacecraft through rigorous demonstrations of its propulsion, communications, and life support systems. For the first time, the public saw the astronauts in orbit through live television originated periodically during the entire mission, labeled a "textbook flight" by NASA. And the press also reported the return of the crew to Cape Kennedy's Skid Strip following recovery, where 3,000 members of the launch team gathered to welcome them home.

Between that eventful day and mid-December, television and radio crews employed by the major broadcasting companies labored feverishly to relocate their studios and electronic gear from Cape Kennedy to NASA's Launch Complex 39 on the Kennedy Space Center proper for the Apollo 8 launch. Meanwhile, the KSC information personnel augmented the on-Center facilities to cope with the even larger numbers of

correspondents expected to cover the flight to the Moon. In order to expedite the access of working newsmen, the Center mailed to requesters 900 badges and completed arrangements with the Eastern Test Range to open the main commuting arteries on the NASA and Air Force installations to the press. As launch day neared, the number of press accredited to report the event broke all records, reaching a new high of 1,300.

News writers, television and radio broadcasters, motion picture crews, technical and scientific authors, and even some representatives of college journals were included in the accreditation list. Most, of course, represented U.S. information media, but there were many as well from Canada, Mexico, Japan, Germany, Denmark, England, Greece, France, South Africa, Italy, Finland, Korea, Belgium, Turkey, Switzerland, Argentina, Australia, Israel, Brazil, Sweden, Austria, Spain, Nicaragua and Yugoslavia. For the first time, in addition to the U.S. television networks, the British Broadcasting Corporation installed equipment at the press site and covered the launch live, transmitting the signal to Europe via Earth satellite — one of those launched earlier by NASA.

Again, as a feature of the Earth-to-Moon flight, live television was provided from the Apollo 8 spacecraft. Earthmen saw, for the first time, what their globe looks like from a vantage point 200,000 miles away in space. And for the first time, the astronauts observed the lunar surface from a height of approximately 60 miles, and transmitted television pictures of that landscape back to Earth. When the flight had terminated with recovery in the Pacific Ocean, it had received more coverage here and overseas than any previous manned space flight, thanks to the diligent efforts of the media and the support provided them by NASA.

Apollo 11 tested NASA's press information organization beyond any previous event. Anticipating record demands, Julian Scheer set his plans in motion long before the launch date. At Kennedy, arrangements were made to take over a two-story office building in Cape Canaveral, vacated by an Apollo contractor reducing his work force, as the news center. NASA announced it would receive press requests for accreditation and 3,497 media representatives for 56 countries responded. There were 2,685 U.S. newsmen and technicians, 118 from Japan, 82 from England, 81 from Italy, 53 from France, 52 from Argentina, 51 from Mexico and smaller numbers from other nations. Even tiny Monaco, Iceland, Switzerland, Rhodesia, New Zealand, and Somalia would cover the historic event.

To assist reporters, NASA prepared information kits, as is the case with every launch, distributing them from Washington, Houston, Huntsville, Ala. and the Kennedy Center. They were issued 30 days in advance

of launch. NASA also played a key role in making it possible for millions of people overseas to receive real-time coverage. The Kennedy Center functions as the launch agency for the Communications Satellite Corporation which develops communications satellites such as Early Bird, Lani Bird and Intelsats that can relay voice, video and data transmissions across the Atlantic and Pacific Oceans. The Eurovision network employed this system to carry the launch story to Europe and also received in-flight television from a NASA tracking station near Madrid, Spain. The networks estimated the total viewing audience for man's first Moon walk at 600,000,000 people.

Some lesser press interest became manifest as the Apollo 12 accreditation neared completion. Of 2,262 media representatives authorized to cover the mission, about 1,500 attended the launch and others visited the Manned Spacecraft Center in Houston. For Apollo 13, the accreditations totaled about 1,900 and 1,200 were actually badged at the Kennedy Center. Again, substantial numbers of foreign correspondents attended both events, representing 30 different nations. A marked innovation was arranged by NASA for the April 1970 launch of Apollo 13. For the first time, a two member press pool was allowed to occupy seats within the Firing Room at KSC and to observe operations in the MSC Mission Control Center throughout the terminal countdown and the flight itself. Thus the press had trained observers at the heart of the action, free to report in real time what they saw and heard.

Not all the accredited press visited KSC. Among the group were correspondents primarily interested in the activities at the Mission Control Center in Houston which controlled the flight through recovery. Many of those who came to Florida for the launch flew to Texas to cover the remainder of the story. With the help of NASA and other field centers, Kennedy ran the Apollo News Center with a force of 66, shifting to 24-hour daily operation commencing one day prior to launch and running through splashdown. The News Center conducted 425 tours for 2,300 press from July 7 through July 18 to familiarize them with KSC's facilities and the mission of the launch organization. The U.S. Information Agency furnished interpreters who assisted foreign press in their reporting.

Following the pattern of previous launches, NASA supplied photographic coverage to the media. A single manned launch may produce requests for as many as 20,000 still photos, 2,000 color transparencies, and miles of 16mm color motion picture film. Some of the choicer camera locations are in the zone of greatest hazard at launch, exposed to the flame, heat and blast pressure of the giant rocket. These locations are usually equipped by the Government and the cameras are remotely controlled.

With a yearly schedule of some 20 launches at Cape Kennedy and

others at the NASA launch complex on the Western Test Range in California, the principal information work of the Kennedy Space Center supports these operations. Between launches the Center satisfies day-by-day the requirements of a resident press corps as well as those who visit the area frequently to obtain information concerning launch facilities and operations. News concerning the Center's activities is routinely provided to the press, radio and television.

Contractors working with NASA at the launch base also conduct information activities related to their contributions to the space program. They assemble press packets and release them before launches in which their rocket stages or spacecraft are involved and observe NASA's policy of the "open door." Failures as well as successes are fully reported to the media who have opportunity after launch to question NASA officials responsible for it.

While there are occasional criticisms of the Center's press relations, the media heartily endorse the freedom of access policy that contrasts sharply with the Soviet Union's policy in disseminating information concerning space launches. The Russians choose to report after-the-fact and only to the extent they consider desirable.

Some of the thousands of reporters who covered the Apollo 11 launch at the Complex 39 Press Site.

A COMMENTATOR'S REACTION

Shortly after Apollo 11 departed the Kennedy Space Center for the Moon, CBS Commentator Walter Cronkite and his colleague, Eric Sevareid, discussed the event in the CBS Studio at the NASA Press Site for the information of their television audience. This was the exchange between them:

Cronkite: *Back here with me in the co-pilot's seat is Eric Sevareid. Eric, it's only right that you should be here. You've seen so many historic moments in your distinguished reporting career. But this, I believe, is your first launch.*

Sevareid: *It is. The launch itself already seems hours and days away, so much has happened. I've seen it only through the eye of the television camera before. You can see it that way. You can hear much of it. But you can't feel it. When you stand out there, on the ground, just with the naked eye to see this thing, this is really a religious experience which you watch as a Biblical scene. The ground really trembles. The air hits you in the face, and all that flame that comes out of the motors is a whole ocean of flame. The clouds on both sides of the Apollo 11 are like atomic mushroom clouds as that column of fire supporting this thing so delicately turns into a plume and finally, it disappears in the clouds like a feathered dart. There's a reverential feeling in the crowd when this happens.*

There wasn't any shouting. When it was up and gone there was a little bit of hand clapping and a lot of people wiping tears away. A sense of relief for the safety of those three frail mortals in that craft that vanished in the sky. That's what people were thinking of, these men, embraced in straps and metal and, I suppose you could say, Walter, embraced in an iron embrace of the sense of duty and purpose. There is a gratitude, a thanksgiving and really, a reverential sensation to watch this.

All the arguments, the sociological arguments, the philosophical arguments you've heard and thought about for weeks and months and years, should we do this instead of something else, they somehow vanish in the cloud of smoke. This can be done and therefore it is done and there isn't any argument.

XXII

The Community Grows

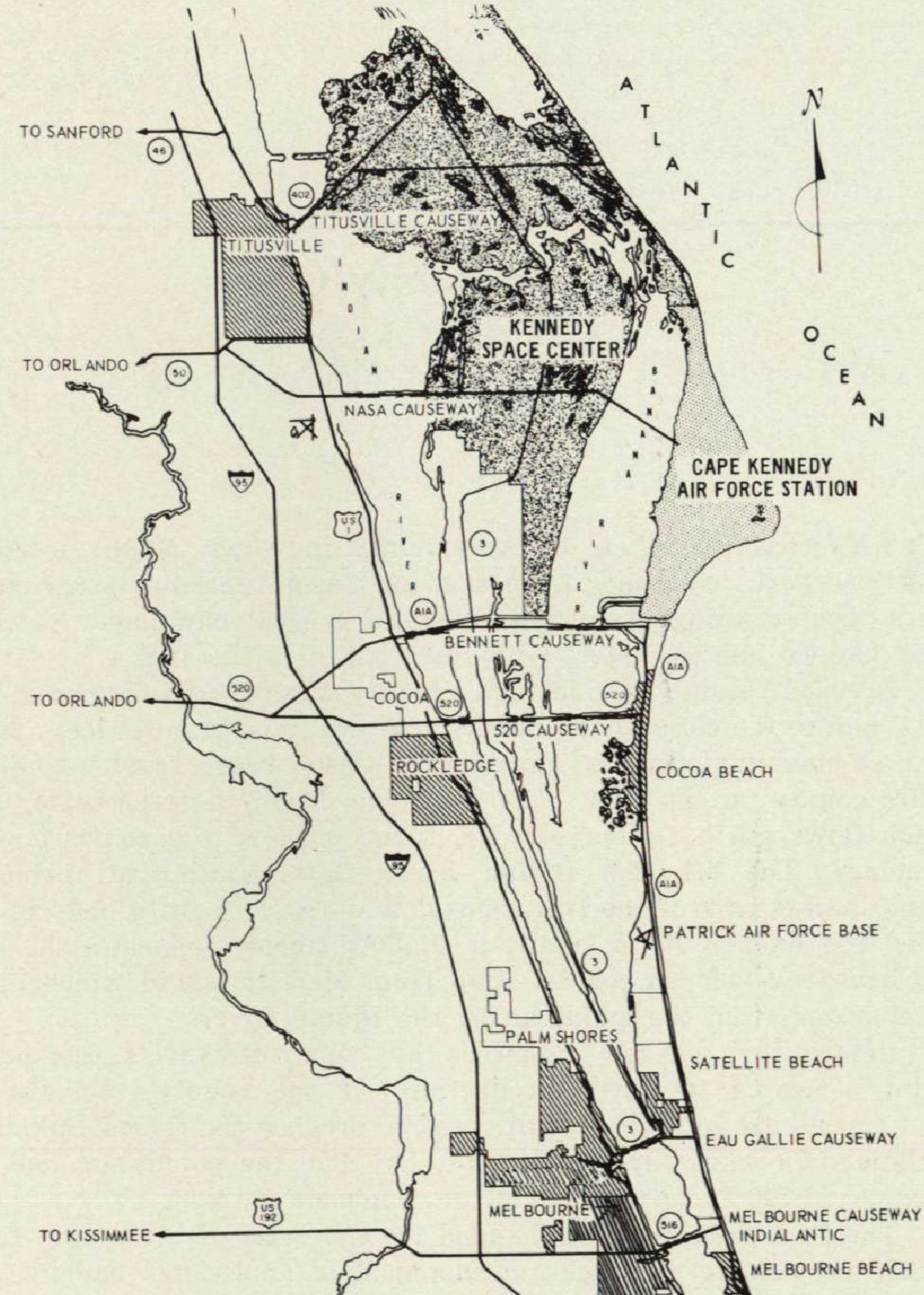
BREVARD County is the community in which NASA located the Spaceport, bringing to the area its second national program in 12 years. The resulting expansion prompted a local newspaper to carry a daily banner line: "Fastest Growing County in the U.S.A."

Brevard became Florida's 25th county when it was formed in March 1844, before the close of the Seminole Wars. It is 72 miles long, 20 miles wide at maximum, and has an Atlantic Ocean beach front bounding the entire county on the East. The St. Johns River, a fresh water stream which flows north to Jacksonville, forms part of the county's western boundary. The brackish Indian River flows southward through the county and is part of the Intracoastal Waterway. A third body of water, called the Banana River, really a shallow lagoon, separates the narrow and heavily developed coastal strip from Merritt Island which, in turn, is separated from the mainland by the Indian River.

Before the rockets triggered the boom, Brevard's economy was mainly oriented to citrus production. Of the county's 839,404 acres, 20,131 acres are intensively cultivated to produce the famed Indian River varieties of oranges and grapefruit. By 1950 the population had slowly risen to 23,700 in an uneventful development pattern.

The first program that changed the character of the county followed a 1955 decision to undertake development of long-range ballistic missile systems for defense purposes. These programs led to the establishment of the Atlantic Missile Range, later changed to Eastern Test Range, and construction of launch complexes and industrial facilities on Cape Kennedy by the Army, Air Force and Navy. Thousands of Government and contractor employees streamed in to operate the Range and conduct rocket tests. The Department of Defense has invested more than $1,500,000,000 in Range facilities.

The county's population experienced explosive growth, climbing to



Most Center and contractor employees reside in Brevard County cities. However, many commute daily from Orlando, New Smyrna Beach, Vero Beach and other Central Florida cities.

91,900 by 1958. Many homes were added, the county-supported public schools system expanded, and new communities with names like Satellite Beach were incorporated. There are 15 cities today.

But the growth prior to 1959, sizeable though it was, turned out to be an understatement of the requirements stemming from the space program. In the next ten years, the population soared to 247,500. The 9,100 housing units tallied in 1950 multiplied to 79,200 by 1969. Property values mushroomed from $22,700,000 in 1950 to $2,349,916,141 in 1969. Motor vehicle registrations increased from 10,545 to 159,253. School enrollment rose from 4,163 to 61,824. Of the students attending public schools in 1969, 50 per cent were Federally connected — that is, some member of the household was employed in the NASA or military program.

State and Federal Governments joined forces in a concerted effort to assist the community in meeting the problems caused by tremendous growth. Shortly after the Apollo program became a national goal in 1961, Florida's then Governor, Farris Bryant, consulted the Space Center's Director Dr. Debus, and the Range Commander, Major General Leighton I. Davis. It was agreed that a Joint Community Impact Coordination Committee should be formed.

Governor Bryant appointed the chairman, the late Max Brewer, a Titusville attorney, who was a member of the State Road Board and therefore in a strategic position to channel road funds into the area. Dr. Debus was represented by Paul Siebeneichen while Major James Clem became the Air Force representative. NASA provided a secretary, John Nelson, who was a member of Siebeneichen's community relations staff.

The committee determined that its primary function would be to provide information to the community concerning the planned buildup of the work force. In turn, the community kept the Committee advised of anticipated problems and plans to resolve them. The Committee also served as a catalyst in bringing the situation to the attention of Federal agencies that could help in such areas as housing, urban planning, school aid, hospital support, water supply, roads and bridges. The Federal Housing Administration encouraged housing construction by insuring loans, endeavoring to pace its commitments in phase with the arrival of newcomers to assure sufficient housing while preventing over development.

The collective effort continued into the Spring of 1965 while subcommittees representing local government, civic groups and business interests pursued specific projects. An East Central Florida Regional Planning Council entered the field, jointly supported by seven contiguous counties, and took active part in community planning and development. Since the community was well on the way to meeting the needs, the

Impact Committee disbanded. Its work was of material benefit — there are 875 miles of improved roads in Brevard County compared with 425 miles in 1958. There are 908 hospital beds, over six times the number available ten years ago. There are 67 schools and two more under construction. Waterways and airports have been improved.

When traffic bottle-necked on two-lane, low level bridges over the Indian and Banana Rivers in 1965, the county appealed to Vice President Hubert H. Humphrey. At his urging, NASA and the Air Force contributed $2,000,000 each to help finance high level bridges that carry four lanes of traffic between Cocoa Beach, on the ocean, and Cocoa, on the mainland 12 miles apart. Federal aid assisted the construction of new facilities at the John F. Kennedy Airport in Melbourne from which jet service is available to the West and North. The Government also contributed to improving Ti-Co Airport south of Titusville, close to NASA's main entrance, which also has jet service to the West and North, and Merritt Island airport for light planes.

The $500,000,000 annual payroll supporting NASA and military activities at the Spaceport and Cape Kennedy feeds back into the local economy and contributes, in part, to the support of municipal and county services through the tax structure. The Federal Government has contributed over $150,000,000 in grants or loans to develop or support essential facilities and services as this listing suggests:

FEDERAL ASSISTANCE

Housing Mortgages Insured	$5,132,000
College Housing Loans	1,739,000
Public/Elderly Housing Loans	12,495,000
Public Facility Loans/Grants	8,657,000
Urban Planning Grants	147,000
Public Schools	35,810,809
Harbors and Waterways	9,600,000
Roads and Bridges	70,579,302
Airport Expansion	1,026,396
Hospitals	3,420,739
County Health Centers	345,864

The quality of education progressed commensurate with growth in the public schools. Brevard operates a junior college in Cocoa that enrolled 700 students its first term and 6,380 in the Fall semester of 1969. This institution is an important factor in the county's proud claim that over 63 per cent of students continue education beyond high school. The college not only offers two years of preparation for senior college entrance but also two years of technical programs plus area-wide vocational

training. There is also an accredited, privately operated engineering college in Melbourne, Florida Institute of Technology, which has also enjoyed a marked increase and expansion of its course offerings. The Institute offers excellent courses at undergraduate and graduate levels for space workers at hours suited to their requirements and work schedules.

In 1963, Dr. Debus and General Davis appealed to the Governor and Legislature for a new State university, convenient to the area, that would offer a wide spectrum of liberal arts, sciences and engineering curricula for Government and contractor personnel and their children now resident in the locality. The State decided to create Florida Technical University and chose a site midway between the Spaceport and Orlando. The University opened in the Fall of 1968 with an enrollment of 1,891 and offered undergraduate level courses devoted to Arts and Sciences, Business Administration, Education and Engineering. The State Board of Regents plans to add graduate training later.

Meanwhile, to serve the technically oriented population, the State embarked upon an experimental program known as the Graduate Engineering Studies System or GENESYS. Instructional buildings were erected at Cape Kennedy, Daytona Beach and Orlando, each community the locale of industries engaged in space or military programs, and in Gainesville where the School of Engineering of the University of Florida serves as the parent institution. Courses are taught either by resident instructors or by closed circuit television from a central classroom, at any of the four locations, with a talk-back feature permitting the remotely located student to exchange information with his teacher. GENESYS confers master's degrees in engineering and contemplates enriching the curriculum to support doctoral level study when resources permit.

NASA funded a number of studies of Brevard's economy in order to make available to local government and civic groups factual information to assist planning. These studies will also serve as useful reference material for Government agencies that may at some future time become involved in similar growth situations elsewhere.

Florida State University completed nine studies, the titles suggesting their content: Growth Cooperation and Concern, Governmental Organization, Finances of County Government, The Educational System, Administration and Financing of Water and Sewer Utilities, Inter-Governmental Cooperation, The Community and The Newcomer, and Adaptation of Newcomers, Community Comparisons.

The University of Florida reported upon Analysis of Population, Analysis of Selected Service Trades, Analysis of Personal Income, Labor Market, the NASA Impact in the Economic Growth and Development of the Cape Kennedy area. The East Central Florida Regional Planning Council received a NASA grant to finance a study titled "The Effect of Atlantic Missile Range Activities on Land, Highways and Utilities

Systems."

NASA provided the studies to State, county and local agencies, especially those concerned with future planning.

In retrospect, Brevard County progressed rapidly since the early 1960s when "swamp pay" was still an inducement to engineers and technicians. This was a bonus offered to people willing to accept jobs in remote, largely undeveloped areas. "Swamp pay" was virtually eliminated several years ago.

As the buildup of facilities and manpower for the Apollo program spurred development in the community, conversely the phasedown in space activities affected the economy of Central Florida. Community leaders and the local press learned the situation at first hand in April 1969 when the content of the FY 1970 space budget became known to Space Center management. The Center Director, Dr. Kurt Debus, summoned civic representatives to a meeting and gave them the facts about the reduced spending. They were told that if the Apollo 11 mission succeeded, the launch rate would reduce to two or three Saturn V's per year in contrast with the five-per-year rate touched off by Apollo 8. In that event, some 5,000 employees would lose their jobs since the Center's new budget would be $90,000,000 less than FY 1969. Apollo 11 succeeded and the phased reduction in contractor ranks began almost immediately. By December 31, 1969, the Center employment dropped to about 21,000 and by April 1970 to 18,000. It would reduce to 17,500 by June 30th.

Inevitably, the impact was widely felt. More housing units were vacated, tax collections dropped slightly, some banks reported less deposits, school enrollment was reported down a little, traffic visibly thinned on the commuting routes to the Space Center. Brevard civic and business interests looked to three alternatives to bolster the economy — more small, non-space related businesses, increased tourism, and a housing market for retired persons.

Center management and contractors worked closely to assure that the cutbacks did not impair the capabilities of the launch organization, which was an obvious concern. As the FY 1971 budget proportions became known, the Center believes that employment will stabilize around the 17,000 figure for the next several years, subject to the Administration's policy decisions and the action of the Congress.

Meanwhile, Civil Service and contractor personnel of the Space Center are taking more active part in community life. Some are members of City Councils, library boards, and recreational and zoning commissions. Others are active in Scouting, mental health programs, parent teacher associations, churches and civic groups. They are helping to shape the future of the community which is the launch base for manned flights to the Moon and deep space, or as Professor Fairbanks observed, "to carry our civilization to other worlds."

XXIII

Triumph and Trial

UNPARALLELED success and painful readjustments packed in 12 short months transformed Fiscal 1970 into the most eventful but trying year in Space Center history.

The triumph of Apollo 11 contrasted sharply with the phased layoff of 5,600 aerospace employees who began to leave while Neil Armstrong, Edwin Aldrin and Michael Collins returned from the Moon. The Center's budget dropped $90,000,000 and the rate of Apollo launches slowed from five to two per year. There were losses in senior management. Albert F. Siepert, Deputy Director since 1963, joined a management research organization. Dr. Rocco A. Petrone, who directed the Apollo 11 launch, moved on to become program director in Washington. Rear Admiral R. O. Middleton returned to the Navy.

Contractors tightened their organizations. Some employees moved to other programs in their companies, the better for experience gained in Apollo operations at KSC. Others discovered few jobs requiring their unique skills in the immediate vicinity. NASA's contractors operated two job clinics in late 1969, inviting other industrial firms to interview men and women leaving the space program. Some received offers which meant leaving Florida.

Concern about the future worried communities where home building abruptly stopped, mortgage foreclosures increased, and the unemployment rate climbed. The last Saturn V would come off the production line in 1971. NASA expected to launch remaining Saturn V vehicles, and some of the Saturn IBs, by 1974. More visits to the Moon and the first experimental space station, or Skylab, would be launched over the 1970-1974 period. Unless a second Skylab emerged in 1974 or 1975, Center employees and the communities anticipated a gap in manned space flights of uncertain duration.

While NASA moved into design of a space shuttle, which will eventually replace costly launch vehicles for many space missions, there was some doubt concerning the role which KSC would play in that program.

Other locations — Utah, California, New Mexico for example — claimed advantages in launch operations over land versus over water. Brevard County fought for the shuttle by petitioning NASA and the Congress. Chairman Olin Teague of the House Subcommittee on Manned Space Flight conducted a public hearing April 10 in Cocoa at the urging of Florida Congressmen Lou Frey and Don Fuqua. Witnesses emphasized Florida's support for the space program and the advantages of the Kennedy Space Center as NASA's operational launch base.

The Eastern Test Range, too, experienced a reduction in employment as some military programs were cut back under the funding pressures created by Viet Nam. For each person released from jobs in the military or NASA projects, service industries in the area lost business and reduced employment also.

Yet there were bright spots in the picture.

President Richard Nixon came to the Apollo 12 launch November 14, 1969, the first time any President had witnessed a manned liftoff. Former President Lyndon B. Johnson attended the Apollo 11 launch July 16, 1969, as the guest of Vice President Agnew. Mr. Agnew attended every Apollo launch in 1969.

Prince Philip of Great Britain toured the Center February 14, 1970 and President Pompidou of the French Republic came to KSC February 26. He expressed the hope that some day European astronauts would visit the Moon. The Royal Automobile Club presented to NASA and the Marion Power Shovel Company a trophy for the Crawler, recognizing the huge machine as a new development in the field of transportation. Donald Buchanan, KSC project manager for this device, received the trophy for NASA at a dinner in London.

KSC and the Air Force Eastern Test Range conducted open house for employees and dependents February 7, 1970. The crowd which responded was estimated at 43,000. NASA's daily bus tours continued to reflect increasing public interest, accommodating more than 1,000,000 visitors in 1969. The Center expanded its agreement with the U.S. Bureau of Sport Fisheries and Wildlife to incorporate within the Merritt Island National Wildlife Refuge practically all the land and water areas acquired by NASA for the national Spaceport. A lunar rock returned by the Apollo 11 astronauts was displayed at KSC in February.

When Hurricane Camille lashed the Gulf Coast in late August, damaging NASA installations at Michoud, Louisiana, and the homes of employees, KSC responded by shipping 5,000 doses of typhoid vaccine, 16 tons of food, clothing and bedding and $1,083.96 cash, the gift of its employees.

Dr. George Low, NASA Deputy Administrator, joined Dr. Kurt

Debus, the Center Director and Miles Ross, his Deputy, in briefing employees, community leaders and the local press February 2, 1970 concerning the budget outlook for FY 1971. KSC would lose more dollars and more jobs but by no means as drastic an impact as that which befell the Center in 1969-70.

In May, the Center laid before NASA management a proposal to consolidate manned launches at Complex 39 and close down the NASA complexes previously utilized for the Saturn I and IB vehicles on Cape Kennedy. NASA accepted the plan which was estimated to yield savings of up to $15,000,000 during the Skylab operations which will commence in 1972.

As Fiscal 1971 opens, KSC will press on with the manned lunar flights, prepare for the Skylab launches, and continue to fly unmanned communications, weather, and scientific satellites. The Center is participating in design studies related to the space shuttle and space station. Despite the reductions, the essential know-how has been retained to meet the requirements of the near and long-range future space projects. There is quiet confidence that the nation will go forward and that KSC will continue to play its key role in exploring outer space.

LOOKING AHEAD

Many accomplishments and some failures marked the 12 years of U.S. space exploration commencing with the launch of Explorer I January 31, 1958. Orbital payloads increased from 30.8 pounds, the weight of our first satellite, to 300,000 pounds, the weight of Apollo and the active third stage of Saturn V during lunar missions. Man traveled 1,900 miles per hour in aircraft in 1958. He travels 25,000 miles per hour in Apollo. The flight altitude record increased from 126,000 feet to 248,000 miles. NASA astronauts spent almost 6,000 hours in space and flew more than 66,000,000 miles in Mercury, Gemini and Apollo.

Fifteen Americans orbited the Moon. Four walked on its surface. Between Explorer I and Apollo 13, NASA successfully launched 154 unmanned spacecraft, 23 of which were international because they involved scientists of other countries who developed experiments for them. These spacecraft returned scientific data from observations of the Sun, Moon, planets, stars, the fields and particles of interplanetary space, and the Earth itself. Practical benefits of immeasurable worth derived from experimental and operational weather, geodetic, navigation, communication and other global systems based upon satellites.

Man overcame gravity and the vacuum of space. Senator Clinton Anderson, chairman of the Senate Aeronautical and Space Sciences Committee, observed that space advances are "achievements that have moved

the minds of men around the globe. A billion children born since 1958 are the first space age generation. Because of space exploration they will learn a new science and a new cosmology. They will have a new view of man and his place in the universe. They will see Earth as a whole and will deal with technology, science and philosophy as a unified experience. The NASA Administrator, Dr. Thomas Paine, commented that "this will have profound consequences which we can just begin to perceive. We can no more fully visualize the effect of this technology on their lives 30 years hence than we could fully visualize today's technology back in 1940."

NASA demonstrated that adversity is part of progress. The January 1967 fire which cost the lives of three astronauts came as a stunning catastrophe. Yet because it happened, Apollo became a safer spacecraft that later carried men to and from the Moon. The accident which crippled Apollo 13 midway to the Moon taxed the capabilities of the crew, the ground organization, and the remaining spacecraft systems beyond all expectation. But men and the equipment they operated proved more than equal to the emergency. So it has been with launch vehicles and spacecraft that failed in performance.

In two areas, communications and weather, vital to every human, space has introduced new dimensions in recent years. Every television receiver brings into the home events reported by satellite systems as they occur. The Olympics in Tokyo were televised internationally for the first time in 1968. Over half a billion people, one-sixth Earth's population, saw man's first steps on the Moon. Live television could not be transmitted across the Atlantic in 1960. In 1965 a global communications system was begun by the Communications Satellite Corporation, an international consortium. Comsat's annual revenues have grown from $2,500,000 to nearly $50,000,000. There were only five ground stations in commercial use in 1965, today there are 52. Before the advent of satellites, a cable circuit from the West Coast to Japan cost $15,000 per month. Now Comsat will provide it for $4,000. Within this year, the Federal Communications Commission has decided to entertain proposals for a U.S. domestic system which would open a wide range of potential services.

One NASA satellite has been employed in demonstrations of educational broadcasting, relaying programs from the East to the West Coast. Satellites have been utilized for high quality and reliable ship-to-shore communications over long distances. A NASA satellite proved the feasibility of maintaining communications with aircraft on transoceanic flights which suggests future space-based air traffic control and navigation systems. Within the span of 10 years, the technology has moved from experiment to commercial use and the 70-nation Intelsat organization grew up around it.

Space has exerted profound influence on meteorology. Satellites detect and track major storms, hurricanes and threatening weather patterns in time to allow adequate warning for air traffic, marine interests, farmers and industry. In 1969, Hurricane Camille was first observed and then tracked by satellite. The path, force and extent of the storm were predicted to permit evacuation of 70,000 people from the Gulf Coast. The Environmental Science Services Administration estimated that without this advance information, some 50,000 people might have perished. In November 1969, Hurricane Laurie threatened the same area. Satellite observations led to predictions that Laurie would not strike the land. The savings resulting from a decision not to evacuate were $3,000,000. Weather satellites have watched every major storm since 1966. Last year alone 12 Atlantic hurricanes, 10 eastern Pacific hurricanes and 17 western Pacific typhoons were identified and tracked by U.S. satellites flown by NASA. The first atlas of Pacific cloud and weather patterns from 1962 to 1969 has been issued. The Navy uses weather satellite pictures for ice patrols and for Antarctic resupply. Airline pilots flying the Atlantic routinely receive weather photos of their route.

Weather satellites are inherently global systems. By means of automatic readout systems, any nation can benefit from the observations of U.S. satellites. Over 50 countries are employing this means to view weather patterns over their territories, an outstanding example of the use of space for benefitting men everywhere. The same countries benefit from cloud picture mosaics produced by the Weather Bureau and made available to Europe, Asia, Australia, North and South America. The mosaic is built up from individual photos and processed by computer, then retransmitted from ESSA ground station via NASA satellites.

Space photography views the entire Earth in a perspective not otherwise available. This has made it possible to study Earth and its atmosphere, to search for new resources, to monitor water supply, to detect air and water pollution, to monitor agricultural activity and forests, to explore the oceans, to track animals and schools of fish. President Nixon described to the United Nations a system of inventorying Earth's resources which, when fully developed, will be available to other nations.

The physical, psychological, technical and scientific frontiers of space stimulated development of new transportation, management and communication systems, manned and automated spacecraft, launch vehicles, cryogenics, tracking systems, computer networks, data links, ground support facilities and new global institutions to manage them. The demands of the space program accelerated the sophistication of computer technology. For Mercury, the computer program contained 40,000 computer "words;" for Apollo 1,500,000 "words." This is one of

the impelling forces that has carried the U.S. computer industry to the forefront, and it is an industry that does $8,000,000,000 worth of business annually. Computer exports have increased 1,400 per cent in the first decade of the space age.

While NASA is usually identified only with space exploits, the agency also has a major responsibility for aviation technology. All U.S. aircraft, civil and military, reflect technical contributions by the forerunner of NASA, the National Advisory Committee on Aeronautics. Today aviation forms the backbone of national and international passenger traffic; in 1942, there were 83,000,000 passengers; in 1969, 168,000,000; in 1942, the U.S. had 423 commercial transports; in 1969 there were 1,781. The industry is America's largest, employing 1,300,000 people with a $14,000,000,000 payroll.

Concerning the dividends to the national economy derived from the space program, Dr. Paine has said: "In hard, cold facts our space effort has cost the nation less than one-half of one per cent of the gross national product, and in return it has made a major contribution to the growth of the GNP from $440,000,000,000 in 1958 to $900,000,000,000 in 1969. I am firmly convinced that the many benefits to our nation and mankind far outweigh the modest investment of $35,000,000,000, or about 2-1/2 per cent of total Federal spending."

Looking to the future, President Nixon charged a Space Task Group chaired by Vice President Agnew to design a space program for the next 30 years. The Task Group proposed continuation of manned lunar exploration, development of an Earth-to-Earth-orbit logistics transportation system, a nuclear powered vehicle for travel between Earth orbit, the Moon and Mars, unmanned spacecraft to explore the outer planets, and a large base in space housing up to 100 scientists, engineers and experimenters. The pace with which this program builds will be determined by the Administration and succeeding Congresses. Mr. Nixon has said the United States will continue space exploration with due consideration to other national priorities.

At the Kennedy Center, the focus is on Apollo 14, while more unmanned spacecraft are prepared for launches this year and next. Alan Shepard, the first U.S. astronaut, will command the next lunar mission. Stuart Roosa is Command Module Pilot and Edgar Mitchell the Lunar Module Pilot. Originally scheduled for launch October 1, 1970, the mission was changed because of the Apollo 13 experience and will now aim at the same Fra Mauro landing site which has not been reached. Some design changes in the spacecraft will be necessary to preclude a mishap like that which befell James Lovell, Jack Swigert and Fred Haise. As a result, the Apollo 14 flight will be delayed.

In 1971 Apollo 15 will visit another lunar site. David Scott will command that mission with James Irwin as Command Module Pilot and Alfred Worden, Lunar Module Pilot. This will be followed by Apollo 16

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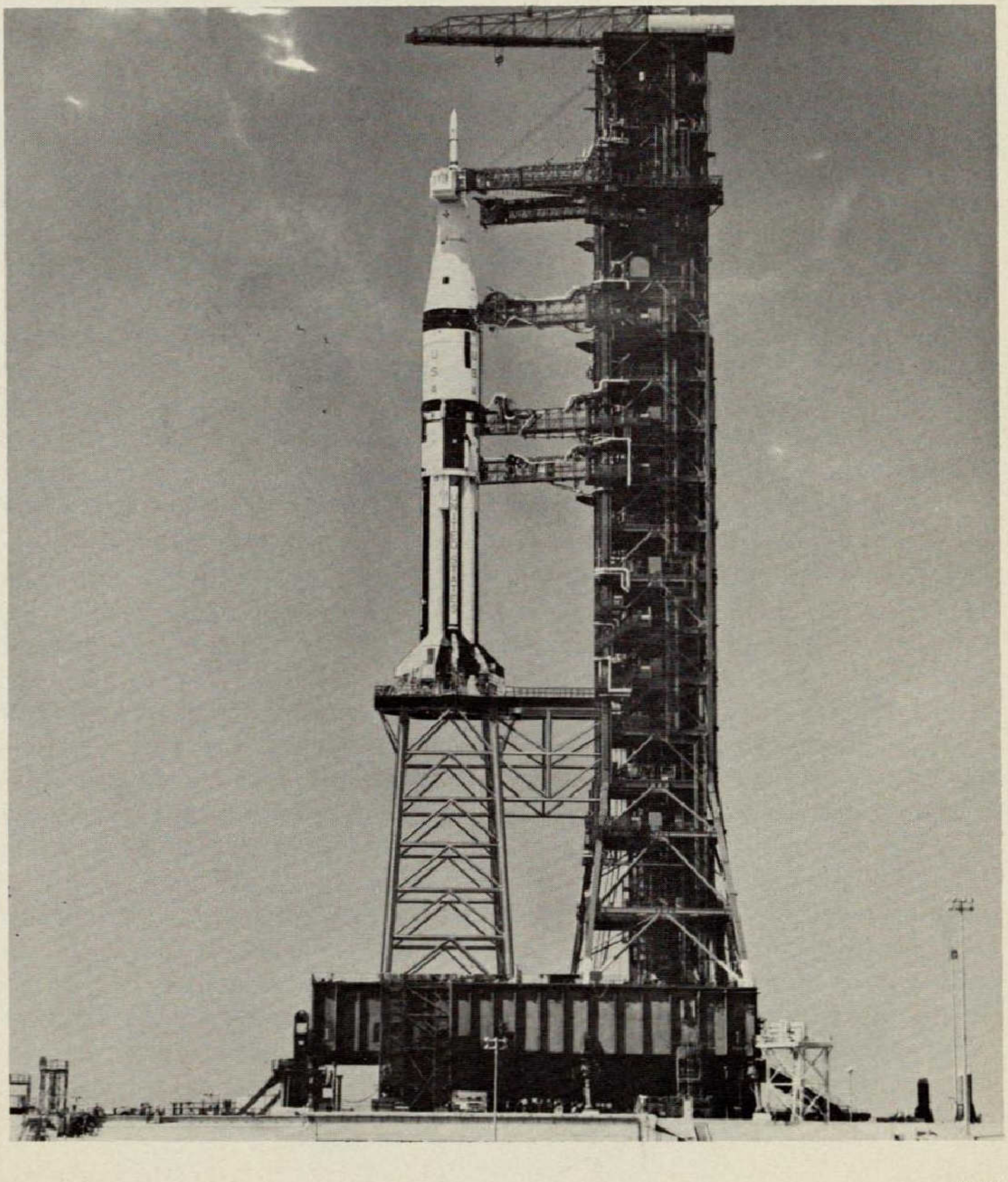
whose crew will, for the first time, have available an electric powered car to extend their reconnaissance on the lunar surface up to distances of 20 miles. Apollo 17 is also planned as a lunar mission in 1972.

During that year KSC will launch the first experimental space station, Skylab, on a Saturn V vehicle. The laboratory will accommodate three astronauts who will be launched next day aboard a Saturn IB vehicle from a specially modified mobile launcher at Complex 39. KSC expects that NASA will realize substantial economies from consolidating

Engineering concept of Saturn IB on launch pad at Complex 39.



manned launches at Complex 39 rather than employing the 11-year-old Complex 34 on Cape Kennedy for the IB vehicles.

The first Skylab crew will remain in orbit 28 days, then return to Earth. A second crew will be flown on the IB rocket for a stay of 56 days followed by a third crew for at least as long a stay. From these missions, NASA will learn more about the effects of zero gravity on the human body, including the capabilities of the crews to conduct useful experiments in weightlessness. Skylab will mount a large telescope for observations of solar phenomena. It will carry other devices to test manufacturing techniques in space and to inventory Earth resources. The Skylab flights will conclude in 1973.

Next year, the final Saturn V vehicle of the 15 ordered for the Apollo program, which comes off the production line in 1971, will propel another crew to the Moon. NASA hopes that limited production of Saturn V vehicles will be resumed at a later time.

Meanwhile, the agency has undertaken design studies of the space logistics transport, commonly referred to as the space shuttle. This is envisaged as a two-stage vehicle, fueled with liquid hydrogen, capable of carrying from 25,000 to 50,000 pounds of payload from Earth to a space station. Each shuttle would have a useful lifetime of 100 flights. Both stages would return to Earth in a horizontal landing mode much like a jet aircraft. KSC has proposed to house the shuttle configuration in the Vehicle Assembly Building, using a mobile launcher and the crawler to transport the flight ready vehicle to the firing site. A landing strip would be constructed nearby for use by either the booster or orbital stage, or both.

Each space launch employing conventional rockets is a one-time affair; that is, the launch vehicle is expended and only the spacecraft, in the case of Mercury, Gemini and Apollo, returns to Earth. The shuttle would be completely reuseable. Hence the cost of transporting payloads into orbit would be drastically reduced. It has been estimated that the present systems cost $1,000 per pound in Earth orbit and $100,000 to carry one pound to the Moon and back. With the shuttle vehicle, it may be possible to reduce the cost to $50 per pound or less in Earth orbit. It will then become economically feasible to undertake full exploitation of space technology for defense, scientific, and commercial purposes.

Concurrently with the shuttle design studies, NASA is looking at the design of a space station module with a projected useful lifetime of 10 years. The module might be large enough to house six to 12 persons who would remain aloft for several months. They would be supported by the shuttle, transporting people to and from the station in orbit, as well as carrying supplies and data between the ground and their laboratory in space. Another vehicle under active study, called a space tug, could be used to recapture a satellite that malfunctioned or consumed

all its power source. The spacecraft could be returned to the space base, made up of an assembly of space station modules, for repair or carried back to Earth for refurbishment and subsequently returned to its assigned location in space. The tug would also propel manned modules between Earth orbit and the Moon, and thus resupply a scientific base for lunar explorers.

For several years NASA has jointly financed with the Atomic Energy Commission and U.S. Air Force a nuclear engine project. Fueled with liquid hydrogen, this would have multiple uses as a transportation stage. It could transport a manned expedition to Mars or other areas in deep space. Dr. Wernher von Braun, NASA's deputy associate administrator for future planning, has described a Mars expedition which would require two years to complete. It would land trained explorers on the planet for a stay up to two months.

In the area of unmanned space missions, the agency has several challenging projects in work while continuing to launch commercial communications satellites for the international consortium and operational weather observation satellites for the Environmental Science Services Administration. A Mariner spacecraft will be launched aboard a Titan-Centaur vehicle in 1973 destined to orbit Mars and return photographs of the planet. Two years later Viking will be launched to soft land on Mars and provide further data. A spacecraft is being designed for 1975 launch that will fly by all the planets over a 10-year period and return better measurements of their environment than science has yet derived.

The President spoke of the future in these terms:

"The space effort is not only an adventure of today, but an investment in tomorrow. Space activities will be a part of our lives for the rest of time. We must think of them as a continuing process. What we do in space must become a regular part of our national life and planned in conjunction with other undertakings which are also important to us."

Mr. Nixon set up the following specific objectives for the space program:

1. Explore the Moon
2. Explore the planets and the universe
3. Reduce the cost of space operations
4. Extend man's capability to live and work in space
5. Hasten and expand the practical applications of space technology
6. Encourage greater international cooperation in space

"As we enter a new decade," the President said, *"we are conscious of the fact that man is also entering a new historic era. For the first time, he has reached beyond his planet; for the rest of time we will think of ourselves as men from the planet Earth. It is my hope that we can plan and work in a way which makes us proud both of the planet from which we come and of our ability to travel beyond it." "*

APOLLO MISSION LAUNCH CHRONOLOGY

MISSION DATE	LAUNCH DATE	LAUNCH VEHICLE	MISSION
Apollo 1	1/27/67	Saturn IB	Planned as first manned Apollo spacecraft flight. Fire in spacecraft during ground test.
Apollo 4	11/9/67	Saturn V	First flight of Apollo/Saturn V space vehicle (unmanned). First use of Complex 39 launch facilities.
Apollo 5	1/22/68	Saturn IB	First flight of lunar module (unmanned).
Apollo 6	4/4/68	Saturn V	Second unmanned Apollo/Saturn V flight.
Apollo 7	10/11/68	Saturn IB	First manned Apollo spacecraft Earth orbital flight.
Apollo 8	12/21/68	Saturn V	First manned Apollo/Saturn V flight. First manned lunar orbit mission.
Apollo 9	3/3/69	Saturn V	First manned lunar module flight. Earth orbit.
Apollo 10	5/18/69	Saturn V	First launch from Complex 39B. First manned flight of lunar module to low lunar orbit.
Apollo 11	7/16/69	Saturn V	First manned lunar landing. Armstrong became first man to set foot on Moon 10:56 pm, EDT, July 20, 1969.
Apollo 12	11/14/69	Saturn V	Second manned lunar landing. Recovered pieces from unmanned Surveyor 3 spacecraft.
Apollo 13	4/11/70	Saturn V	Scheduled to be third manned luanr landing. Mission aborted en route to Moon, safe landing effected in Pacific.

NOTE: On April 24, 1967, Dr. George E. Mueller, Associate Administrator for Manned Space Flight, NASA, officially designated the test in which astronauts Grissom, White, and Chaffee lost their lives as Apollo 1 and also announced that the forthcoming Saturn V flight would be called Apollo 4. There are no missions or flights officially designated as Apollo 2 and 3.

Ninety-first Congress

in the

House of Representatives, U.S.

July 24, 1969.

Whereas the United States has completed its first decade in space, with the combined talents of Government, industry, and education having been effectively employed in the space program to open a new frontier; and

Whereas in the development of the space program science and technology have been brought to new levels of achievement, and inspiration and intellectual stimulation have been generated not only for the people of the United States but for the entire world; and

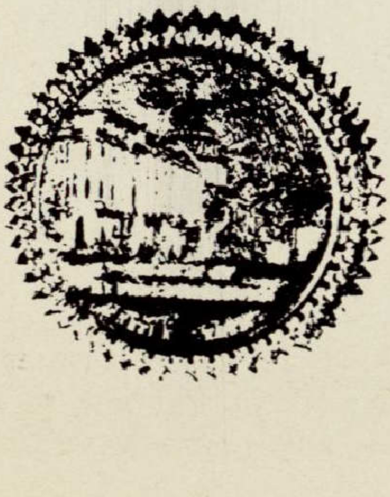
Whereas the mission of Apollo 11, representing as it does the first real step by mankind into the universe beyond the planet on which we live, is not only a great adventure but demonstrates substantial progress toward the achievement of the objectives originally expressed in the National Aeronautics and Space Act of 1958; and

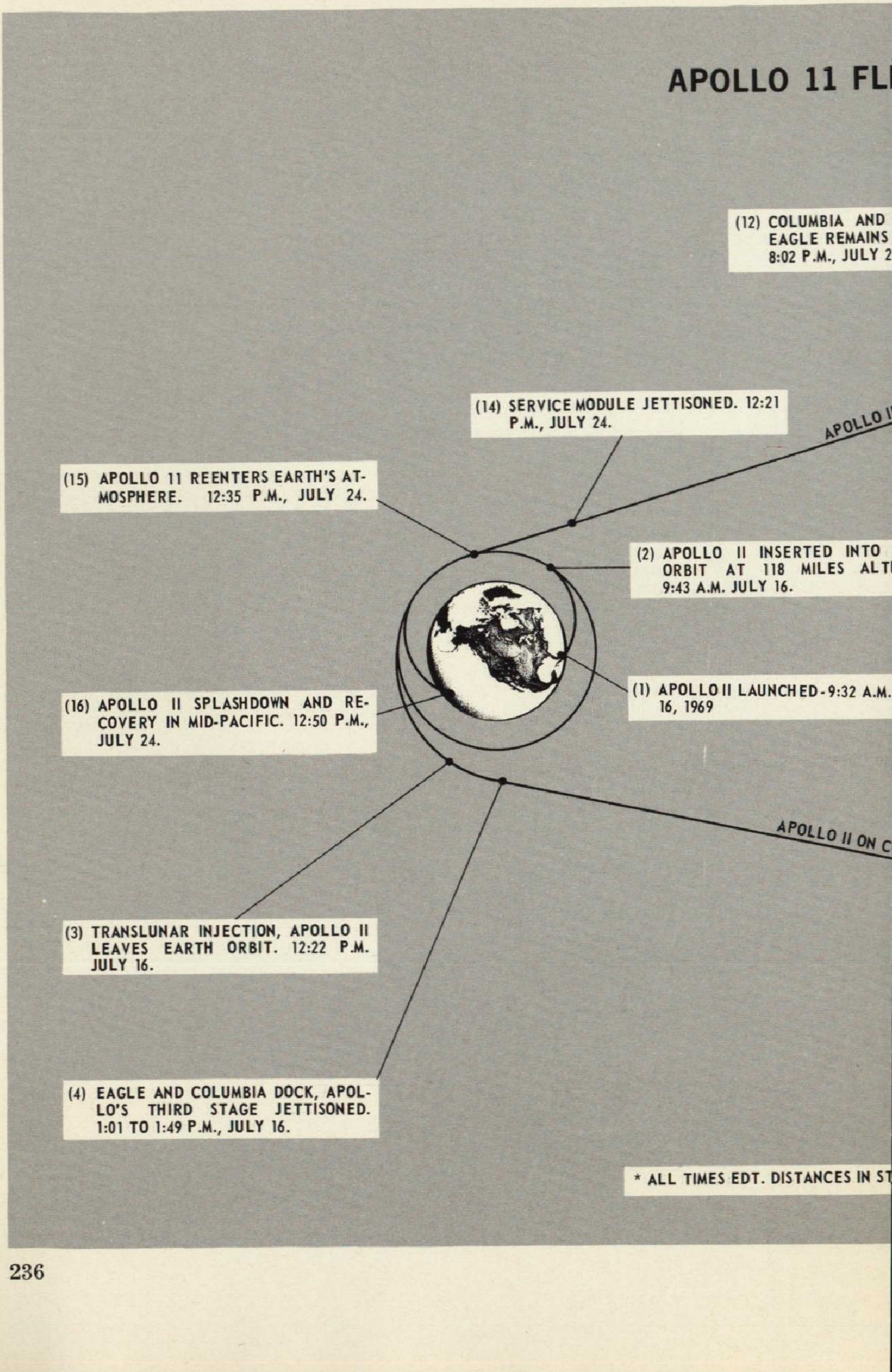
Whereas the achievement of these objectives—the expansion of human knowledge, the improvement of aeronautical and space vehicles, the development of information useful to our national defense, and the preservation of the United States' role as a leader in space science and technology and its application for peaceful purposes, with international cooperation in the peaceful application of the program's results—has importance for our Nation far beyond the specific areas of science and technology to which the program directly relates; and

Whereas this mission provides a uniquely appropriate occasion for expressing public appreciation of the past achievements of the space program and public recognition of the potential of such program for benefits to mankind in the future: Now, therefore, be it

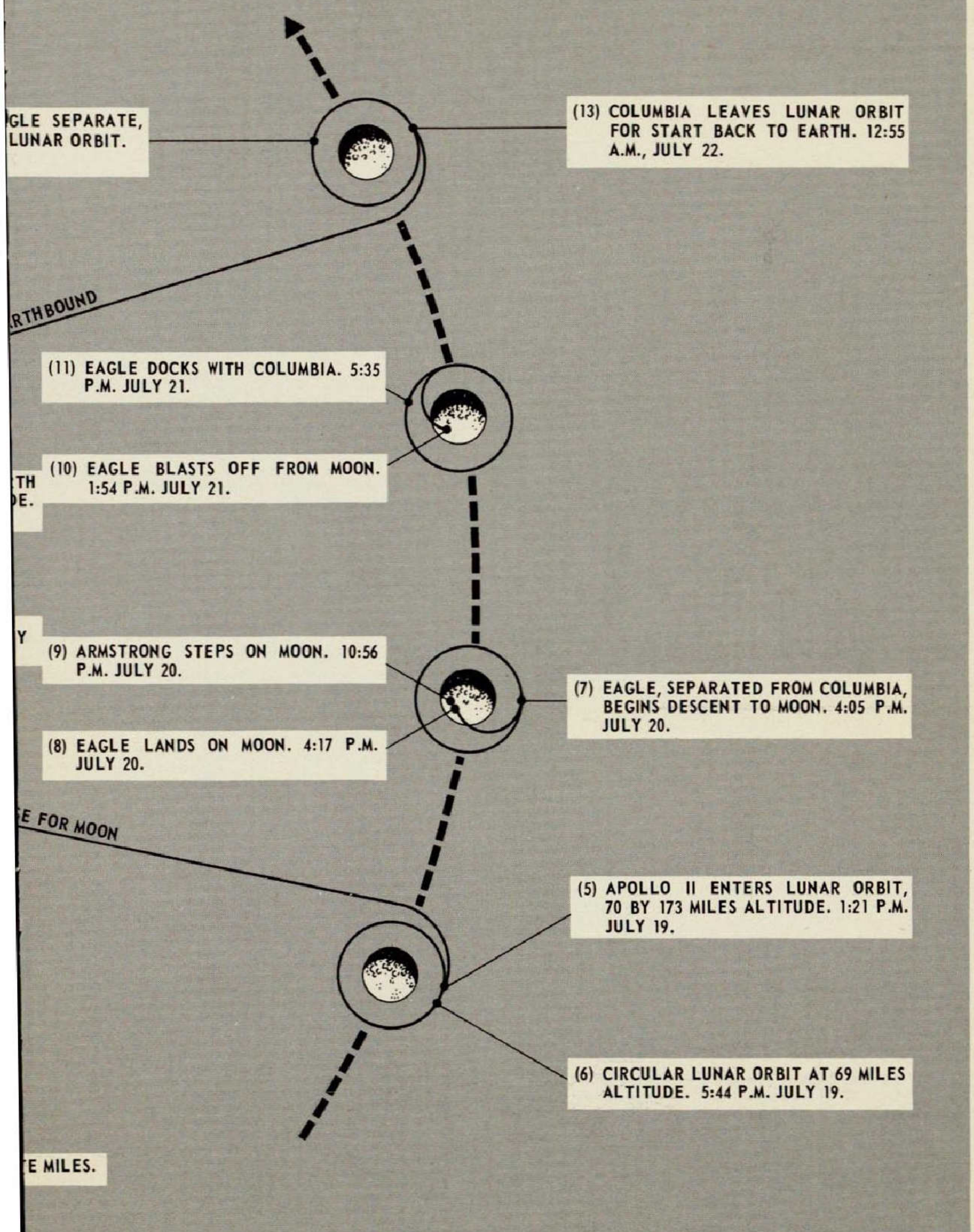
Resolved, That the House of Representatives commends the magnificent team of men and women throughout the United States and the world at large, in Government, industry, and education, who have contributed so much to the accomplishments of our national space program; and expresses gratitude and appreciation, for itself and on behalf of the American people, for the outstanding dedication and tireless effort of all those who have been associated with the Apollo program in general and the Apollo 11 mission in particular.

Attest:




APOLLO 11 FL
(12) COLUMBIA AND
EAGLE REMAINS
8:02 P.M., JULY 2
(14) SERVICE MODULE JETTISONED. 12:21 P.M., JULY 24.
APOLLO 1
(15) APOLLO 11 REENTERS EARTH'S ATMOSPHERE. 12:35 P.M., JULY 24.
(2) APOLLO II INSERTED INTO
ORBIT AT 118 MILES ALT
9:43 A.M. JULY 16.
(1) APOLLO II LAUNCHED - 9:32 A.M.
16, 1969
(16) APOLLO II SPLASHDOWN AND RECOVERY IN MID-PACIFIC. 12:50 P.M., JULY 24.
APOLLO II ON C
(3) TRANSLUNAR INJECTION, APOLLO II LEAVES EARTH ORBIT. 12:22 P.M. JULY 16.
(4) EAGLE AND COLUMBIA DOCK, APOLLO'S THIRD STAGE JETTISONED. 1:01 TO 1:49 P.M., JULY 16.
* ALL TIMES EDT. DISTANCES IN ST

HT PROFILE *


GLE SEPARATE,
LUNAR ORBIT.
(13) COLUMBIA LEAVES LUNAR ORBIT FOR START BACK TO EARTH. 12:55 A.M., JULY 22.
RTHBOUND
(11) EAGLE DOCKS WITH COLUMBIA. 5:35 P.M. JULY 21.
(10) EAGLE BLASTS OFF FROM MOON. 1:54 P.M. JULY 21.
TH
E.
Y
(9) ARMSTRONG STEPS ON MOON. 10:56 P.M. JULY 20.
(7) EAGLE, SEPARATED FROM COLUMBIA, BEGINS DESCENT TO MOON. 4:05 P.M. JULY 20.
(8) EAGLE LANDS ON MOON. 4:17 P.M. JULY 20.
E FOR MOON
(5) APOLLO II ENTERS LUNAR ORBIT, 70 BY 173 MILES ALTITUDE. 1:21 P.M. JULY 19.
(6) CIRCULAR LUNAR ORBIT AT 69 MILES ALTITUDE. 5:44 P.M. JULY 19.
E MILES.

THIS IS NASA

NASA HEADQUARTERS, WASHINGTON, D. C.
Formulates policy and coordinates activities of space flight centers, research centers and other installations through the Office of Tracking and Data Acquisition, the Office of Manned Space Flight, the Office of Space Science and Applications and the Office of Advanced Research and Technology. The Headquarters administers NASA's legislative and international affairs, public affairs, industry and university relationships, Department of Defense relationships and technology utilization.

AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA
Performs laboratory and flight research in unmanned space flight projects and aeronautics. Space flight projects involve management of scientific probes and satellites and payloads for flight experiments.

FLIGHT RESEARCH CENTER, EDWARDS, CALIFORNIA
Concerned with manned flight within and outside the atmosphere including low speed, supersonic, hypersonic and reentry flight, and air operations and safety problems.

GODDARD SPACE FLIGHT CENTER, GREENBELT, MARYLAND
Develops and manages unmanned earth-orbiting satellite and sounding rocket projects including scientific, communications and meteorological satellites. Nerve center for worldwide tracking and communications networks. Manages Delta Programs.

JET PROPULSION LABORATORY, PASADENA, CALIFORNIA
Develops spacecraft for unmanned lunar and planetary exploration and operates worldwide deep space tracking and control network. Operated for NASA by California Institute of Technology.

LANGLEY RESEARCH CENTER, HAMPTON, VIRGINIA
Provides technology for unmanned and manned exploration of space and for improvement of performance and utility of aircraft. Develops and operates simulators for supersonic transport and lunar landing project.

LEWIS RESEARCH CENTER, CLEVELAND, OHIO
Primary mission is propulsion and space power generation including chemical, nuclear and electric rocket propulsion, advanced turbojet power plants, fuels, lubricants, plasmas and magnetohydrodynamics. Manages Agena and Centaur Programs.

MANNED SPACECRAFT CENTER, HOUSTON, TEXAS
Designs, develops and tests manned spacecraft and associated systems, selects and trains astronauts, and controls manned space flights.

MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA
Designs, develops and procures Saturn launch vehicles, supervises the Michoud, Louisiana manufacturing facility where booster stages are fabricated, and the Mississippi Test Facility for static tests.

NUCLEAR ROCKET DEVELOPMENT STATION, JACKASS FLATS, NEVADA
Managed by the Space Nuclear Propulsion Office, a joint operation of NASA and the Atomic Energy Commission. Provides facilities for development of reactor technology and the nuclear engine and rocket stage.

WALLOPS STATION, WALLOPS ISLAND, VIRGINIA
Checks out payloads, prepares and launches light vehicles including sounding rockets, carrying experiments of U. S. and Free World scientists and institutions. Tracks vehicles, obtains and reduces data.

WESTERN OPERATIONS OFFICE, SANTA MONICA, CALIFORNIA
Serves all operational interests of the agency in the West as a branch of NASA Hq. Primary mission of the Office is contract negotiation and management.